AQUATIC ENVIRONMENTS

PROFESSIONAL DEVELOPMENT
CONTINUING EDUCATION COURSE

Technical Learning College

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Call your State agency to see if the course is accepted.

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Important Information about this Manual

This CEU course manual has been prepared to educate pesticide applicators and operators in general safety awareness of dealing with the often-complex and various pesticide treatment devices, methods, and applications.

This manual covers general laws, regulations, required procedures, and accepted policies relating to the use of pesticides. It should be noted, however, that the regulation of pesticides and hazardous materials is an ongoing process and subject to change over time. For this reason, a list of resources is provided to assist in obtaining the most up-to-date information on various subjects.

This manual is not a guidance document for applicators or operators who are involved with pesticides. It is not designed to meet the requirements of the United States Environmental Protection Agency or your local State environmental protection agency or health department.

This CEU course manual provides general pesticide safety awareness and should not be used as a basis for pesticide treatment method/device guidance. This document is not a detailed pesticide information resource or a source or remedy for poison control.

Technical Learning College or Technical Learning Consultants, Inc. make no warranty, guarantee or representation as to the absolute correctness or appropriateness of the information in this manual and assumes no responsibility in connection with the implementation of this information. It cannot be assumed that this manual contains all measures and concepts required for specific conditions or circumstances. This document is to be used solely for educational purposes only and is not considered a legal document.

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals.

Never dispose of containers where they may contaminate water supplies or natural waterways.

Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides. Never burn pesticide containers.

Individuals who are responsible for pesticide storage, mixing, and application should obtain and comply with the most recent federal, state, and local regulations relevant to these sites and are urged to consult with the EPA and other appropriate federal, state, and local agencies.

Example of non-chemical weed control (Mechanical) methods.

TLC
P.O. Box 3060
Chino Valley, AZ 86323

Herbicides and pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits and/or vegetables ready to be picked.

Dispose of empty containers carefully. Follow label instructions for disposal. Never reuse containers. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Do not pour down sink or toilet. Consult your county agricultural commissioner for correct ways of disposing of excess pesticides.

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Technical Learning College's Scope and Function

Welcome to the Program,

Technical Learning College (TLC) offers affordable continuing education for today's working professionals who need to maintain licenses or certifications. TLC holds several different governmental agency approvals for granting of continuing education credit.

TLC's delivery method of continuing education can include traditional types of classroom lectures and distance-based courses or independent study. TLC's distance based or independent study courses are offered in a print- based format and you are welcome to examine this material on your computer with no obligation. We will beat any other training competitor's price for the same CEU material or classroom training.

Our courses are designed to be flexible and for you do finish the material on your leisure. Students can also receive course materials through the mail. The CEU course or e-manual will contain all your lessons, activities and assignments. All of TLC's CEU courses allow students to submit assignments using e-mail or fax, or by postal mail. (See the course description for more information.)

Students have direct contact with their instructor—primarily by e-mail or telephone. TLC's CEU courses may use such technologies as the World Wide Web, e-mail, CD-ROMs, videotapes and hard copies. (See the course description.) Make sure you have access to the necessary equipment before enrolling, i.e., printer, Microsoft Word and/or Adobe Acrobat Reader. Some courses may require proctored closed-book exams depending upon your state or employer requirements.

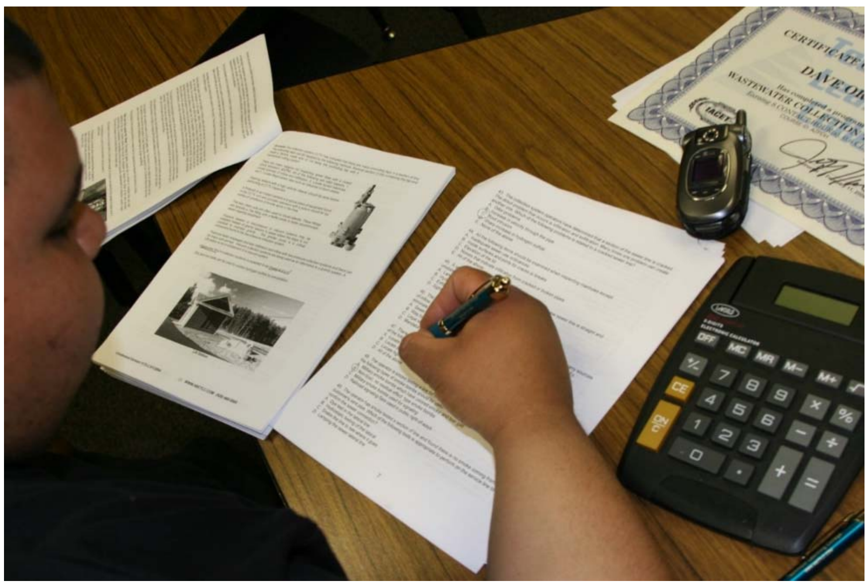
Flexible Learning
At TLC, there are no scheduled online sessions or passwords you need contend with, nor are you required to participate in learning teams or groups designed for the "typical" younger campus based student. You will work at your own pace, completing assignments in time frames that work best for you. TLC's method of flexible individualized instruction is designed to provide each student the guidance and support needed for successful course completion.

Course Structure
TLC's online courses combine the best of online delivery and traditional university textbooks. You can easily find the course syllabus, course content, assignments, and the post-exam (Assignment). This student friendly course design allows you the most flexibility in choosing when and where you will study.

Classroom of One
TLC offers you the best of both worlds. You learn on your own terms, on your own time, but you are never on your own. Once enrolled, you will be assigned a personal Student Service Representative who works with you on an individualized basis throughout your program of study. Course specific faculty members are assigned at the beginning of each course providing the academic support you need to successfully complete each course.

No Data Mining Policy
Unlike most online training providers, we do not use passwords or will upload intrusive data mining software onto your computer. We do not use any type of artificial intelligence in our program. Nor will we sell you any other product or sell your data to others as with many of our competitors. Unlike our training competitors, we have a telephone and we humanly answer.

Satisfaction Guaranteed
We have many years of experience, dealing with thousands of students. We assure you, our customer satisfaction is second to none. This is one reason we have taught more than 20,000 students.



We welcome you to do the electronic version of the assignment and submit the answer key and registration to us either by fax or e-mail. If you need this assignment graded and a certificate of completion within a 48-hour turn around, prepare to pay an additional rush charge of $50.

We welcome you to complete the assignment in Word.

Once we grade it, we will mail a certificate of completion to you. Call us if you need any help.

Contact Numbers
Fax (928) 468-0675
Email Info@tlch2o.com
Telephone (866) 557-1746

Aquatic Environments CEU Training Course Description

Welcome to the world of aquatic lake maintenance and 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 control and 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.

This course is a review of various and complex treated wastewater storage methods utilized at recreational lakes and ponds, including fresh surface water maintenance and weed control, general lake water quality, sampling techniques, pest and weed identification and various pest control methods, algae control and related subjects. This course is general in nature and not state specific but will contain different effluent and surface water treatment methods, techniques and ideas. You will not need any other materials for this course.

Intended Audience

Personnel that work at Parks, Golf Courses, Wetlands, Irrigation Districts or Recharge projects. This includes Wastewater Treatment Operators, Water Treatment Operators, Pesticide Applicators and Tour Guides. The target audience for this course is the person interested in working at a recreational lake or pond, or a surface water intake facility and/or wishing to maintain CEUs for certification license or to learn how to do the job safely and effectively, and/or to meet education needs for promotion.

As a member of the aquatic maintenance 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.

Course Procedures for Registration and Support
All of Technical Learning College's correspondence courses have complete registration and support services offered. Delivery of services will include e-mail, web site, telephone, fax and mail support. TLC will attempt immediate and prompt service. Students will be tracked by a unique number will be assigned to the student.

Instructions for Written Assignments
The Aquatic Environments CEU training course uses a multiple choice style answer key. You can write your answers in this manual or type out your own answer key.

Feedback Mechanism (examination procedures)
Each student will receive a feedback form as part of his or her study packet. You will be able to find this form in the front of the assignment.

Security and Integrity
All students are required to do their own work. All lesson sheets and final exams are not returned to the student to discourage sharing of answers. Any fraud or deceit and the student will forfeit all fees and the appropriate agency will be notified.

Grading Criteria
TLC will offer the student either pass/fail or a standard letter grading assignment. If TLC is not notified, you will only receive a pass/fail notice.

Required Texts
This short CEU training course will not require any other materials. This course comes complete.

Pesticide and Herbicide Terms, Abbreviations, and Acronyms
TLC provides a glossary that defines, in non-technical language, commonly used environmental terms appearing in publications and materials. It also explains abbreviations and acronyms used throughout the EPA and other governmental agencies. You can find the glossary in the rear of this manual.

Recordkeeping and Reporting Practices
TLC will keep all student records for a minimum of five years. It is the student's responsibility to give the completion certificate to the appropriate agencies. TLC will complete and return to you the forms necessary for your certificate renewal.

ADA Compliance
TLC will make reasonable accommodations for persons with documented disabilities. Students should notify TLC and their instructors of any special needs. Course content may vary from this outline to meet the needs of this particular group.

Note to students: Keep a copy of everything that you submit. If your work is lost you can submit your copy for grading. If you do not receive your graded assignment or quiz results within two or three weeks after submitting it, please contact your instructor. We expect every student to produce his/her original, independent work. Any student whose work indicates a violation of the Academic Misconduct Policy (cheating, plagiarism) can expect penalties as specified in the Student Handbook, which is available through Student Services; contact them at (928) 468-0665.

You will have 90 days from receipt of this manual to complete in order to receive your Continuing Education Units (**CEUs**) or Professional Development Hours (**PDHs**). A score of 70% or better is necessary to pass this course. If you should need any assistance, please email all concerns or call us. If possible e-mail the final test to info@tlch2o.com or fax (928)468-0675.

Course Objective:
To provide continuing education training in aquatic plant identification, aquatic plant control, effective, safe herbicide applications, biological and mechanical treatment methods.

Educational Mission
The educational mission of TLC is:

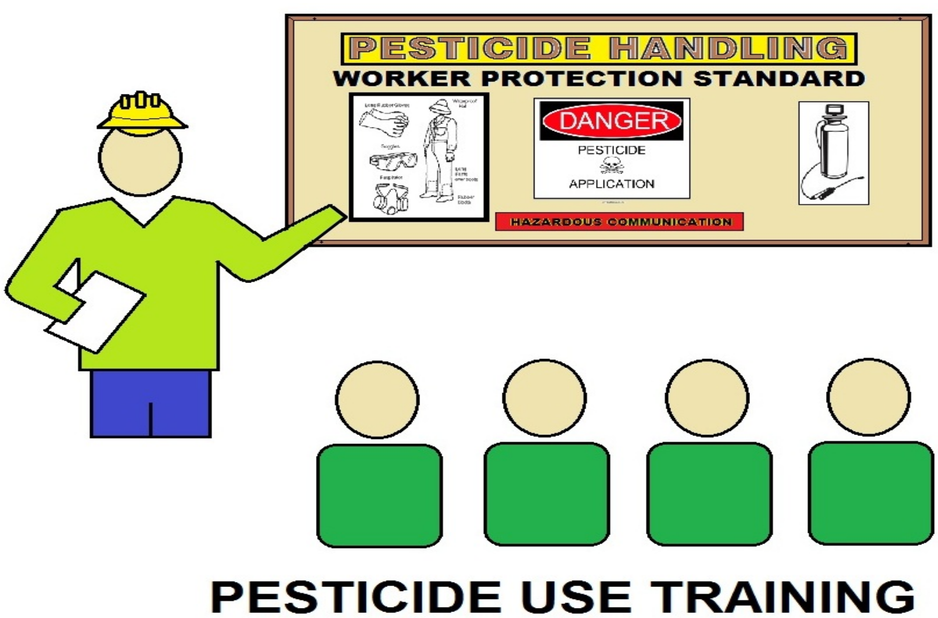
To provide TLC students with comprehensive and ongoing training in the theory and skills needed for the pesticide application field,

To provide TLC students with opportunities to apply and understand the theory and skills needed for operator certification,

To provide opportunities for TLC students to learn and practice environmental educational skills with members of the community for the purpose of sharing diverse perspectives and experience,

To provide a forum in which students can exchange experiences and ideas related to pesticide education,

To provide a forum for the collection and dissemination of current information related to pesticide education, and to maintain an environment that nurtures academic and personal growth.



Precept-Based Training Course

This training course is based upon a form of induction training, made of topical and technical precepts. The training topics are made up of “micro-content” or “precepts”– or small chunks of information that can be easily digested. These bite-size pieces of technical information are considered to be one of the most effective ways of teaching people new information because it helps the mind retain knowledge easier. Micro-learning or precept-based training doesn’t rely on the student to process a large amount of information before breaking it down. Our method includes short modules with clearly defined learning goals for each section. This method allows a student to hone in on a particular skill, then given the opportunity to exhibit their knowledge in the final assessment.

A second certificate of completion for a second State Agency $25 processing fee.

Many States and employers require the final exam to be proctored.

Table of Contents

This course contains EPA's federal snd State rule requirements. Please be aware that each state implements drinking water and/or pesticide regulations that may be more stringent than EPA's or State regulations. Check with your state environmental agency for more information.

2017 Changes EPA's Farm Worker Protection Standard

In late 2015 the Environmental Protection Agency issued the long awaited revision to the Worker Protection Standard (WPS). This law it is now technically active and it will be enforced. Please keep in mind that the WPS covers both restricted use AND general use pesticides. This course is not for worker and/or handler training. Always follow the label and your State Pesticide Agency rules.

Aquatic Plant/Animal Abbreviations

A - adjective
alt. - alternative name (synonym)
AS. - Anglo-Saxon
Comb. Form. - Combining form
Dan. - Danish
Dim. - diminutive
E. - English
esp. - especially
Fr. - French
fr. - from
G. - German
Gael. - Gaelic
Goth. - gothic
Gr. - Greek
Icel. - Icelandic
i.e. - for example
Ir. - Irish
It. - Italian
L. - Latin
LL. - Low Latin, Late Latin
MD. - Middle Dutch
ME. - Middle English
n. - noun
NL. - New Latin
OE. - Old English
O.Fr. - Old French
OHG. - Old High German
ON. - Old Norse
perh. - perhaps
pl. - plural
pp. - past participle
prob. - probably
pres. part. - present participle
Scand. - Scandinavian
Skt. – Sanskrit
specif. - specifically
Sw. - Swedish
vt. - verb transitive
W. - Welsh

Ponds and Lake Information

A pond is a body of water and is often shallow enough to support rooted plants. Many times plants grow all the way across a shallow pond. Water temperature is fairly even from top to bottom and changes with air temperature. There is little wave action and the bottom is usually covered with mud. Plants can, and often do, grow along the pond edge. The amount of dissolved oxygen may vary greatly during a day. In really cold places, the entire pond can freeze solid.

A lake is an inland body of water of considerable size. Lakes can range in size from small ponds to huge bodies of water such the Great Lakes in the U.S. Lakes and rivers are closely tied. Some lakes are the source for some rivers. Important rivers most often originate from lakes. Some rivers end in lakes. Since both rivers and lakes are freshwater and flow in and out of each other, they share similar characteristics and many species reside in both habitats.

What Are Freshwater Wetlands?
The term "wetlands" encompasses a wide variety of aquatic habitats including swamps, marshes, bogs, prairie potholes, flood plains, and fens. Natural wetlands are lands which, due to geological or ecological factors, have a natural supply of water -- either from tidal flows, flooding rivers, connections with groundwater, or because they are perched above aquifers or potholes. Wetlands are covered or soaked for at least a part, and often all of the year. This makes wetlands intermediaries between terrestrial and aquatic ecosystems. They are neither one nor the other, they are both.

What is a Marsh?
A freshwater marsh is an inland area inundated with 1-6 feet of water, containing a variety of plants, including perennial grasses and forbs and bushes, rather than trees, as in swamps. Marshes have an interesting mix of plant and animal life, one that effectively demonstrates the interconnectedness of living things. They are home to yellow-headed and red-winged blackbirds, herons, egrets, rails, bitterns, moorhens, ducks and geese. Most migratory species, in fact, rely on a network of wetlands to get from their southern habitats to nest sites further north.

Muskrats are central to many marshes, keeping aggressive plants in check and crafting bird protection by carving out habitat. Minks and otters frequent wetlands. Raccoons, opossums, and even moose can be found foraging around marshes, particularly when water levels drop. Marshes also host frogs, turtles, snakes, salamanders, and an immense variety of insects, including aquatic, flying, and grazing insects.

What is a Swamp?
Swamps are slow moving streams, rivers or isolated depressions that host trees and some shrubs.

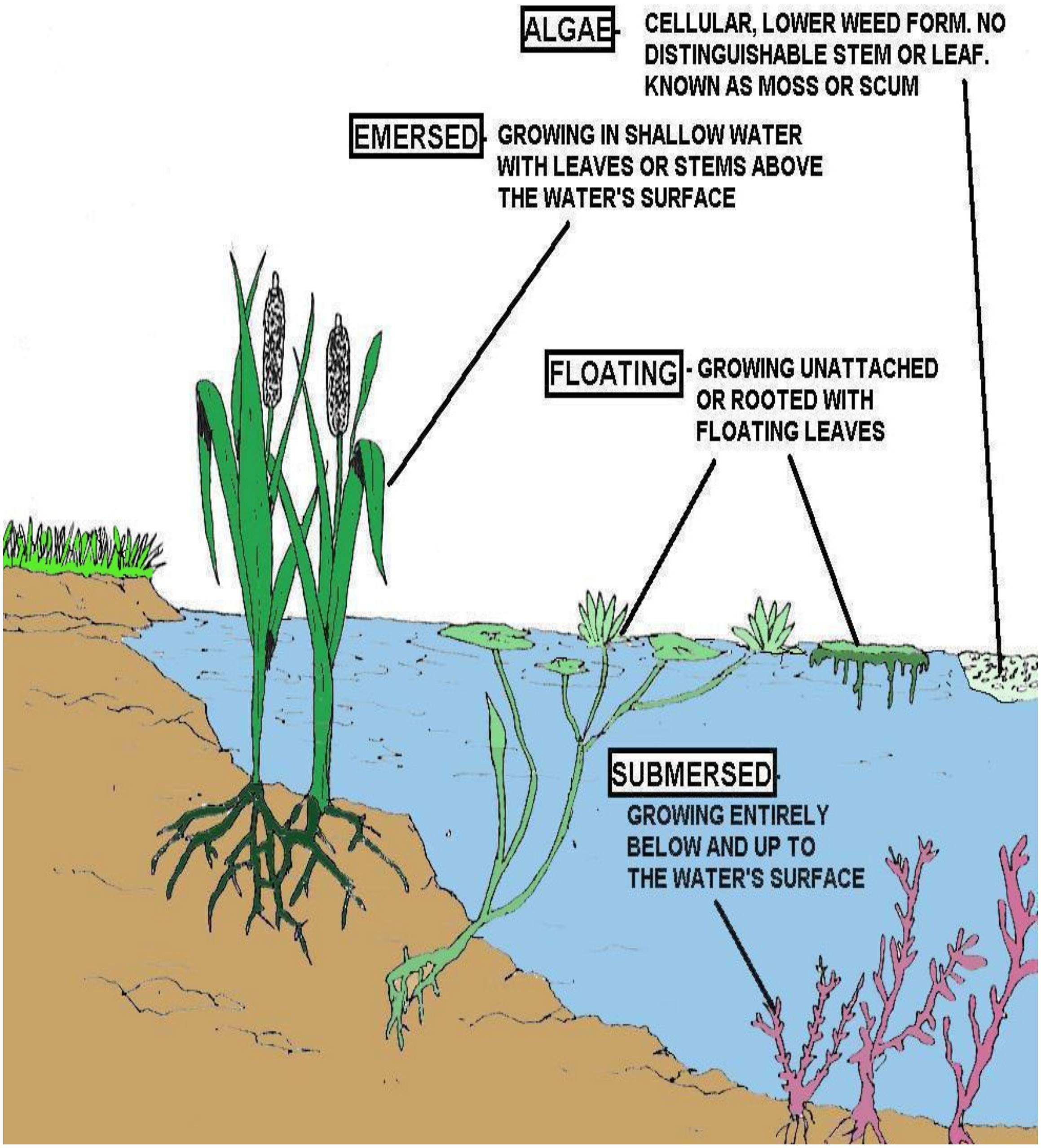
What is a Bog?
A bog is a peat-accumulating wetland. Some shrubs and evergreens grow in bogs, as do mosses. Most water comes from precipitation. There is usually no direct inflow or outflow of water.

What is a Prairie Pothole?
A prairie pothole is a wetland area found in the northern Great Plains. These shallow or bowl-like depressions have variable wetness. They are often used for breeding by birds. Prairie potholes are not wet year-round.

What is a Riparian Marsh?
Marshes that occur along rivers are called riparian marshes. These marshes serve two ecological roles: to absorb excess water when river levels are high and to release water when river levels are low. These balancing forces help prevent floods and droughts. However, for the past 100 years mankind has straightened and deepened rivers in order to make them more accessible for commerce. The unfortunate side effect is the loss of riparian marshes. Today, very few riparian marshes are left. Some scientists believe that the great Mississippi River flood of 1993 was worsened, in part, by the loss of these wetlands.

Pond Succession
A geological event, such as a glacier or sink hole, can create a pond. Ponds are nothing more than shallow holes where water collects. Yet, if left alone, ponds will fill in with dirt and debris until they become land. It often takes hundreds of years for a pond to be transformed from a body of clear water into soil.

Aquatic plants are listed in four groups according to the habitats in which they are usually found. The four groups are algae, floating weeds, emersed (above water) weeds and submersed (underwater) weeds.


ALGAE- CELLULAR, LOWER WEED FORM. NO DISTINGUISHABLE STEM OR LEAF. KNOWN AS MOSS OR SCUM
EMERSED- GROWING IN SHALLOW WATER WITH LEAVES OR STEMS ABOVE THE WATER'S SURFACE
FLOATING- GROWING UNATTACHED OR ROOTED WITH FLOATING LEAVES
SUBMERSED- GROWING ENTIRELY BELOW AND UP TO THE WATER'S SURFACE

The Four Stages of Pond Succession

1) As a pond develops, seeds are flown in by birds or by wind, and land animals come to inhabit the pond. These are the pond pioneers.
2) As more creatures arrive the debris on the bottom increases. Pondweed and other submergent vegetation appear and soon grow all along the bottom.
3) Emergents then appear on the edges of the pond. Over time, sometimes hundreds of years, as ponds plants grow, die and decompose, layers of debris build up. These layers of decaying matter raise the pond floor over the years.
4) After some time, the pond floor is close enough to the bottom that emergents can grow all the way across the floor. When this happens, the pond becomes a marsh. Many interesting creatures can reside in the shallow muddy waters of marshes. (Marshes can be created in other ways, also.) The marsh continues to fill in with dirt and debris. Eventually trees grow in the water. It is now a swamp. Over time, the swamp may dry out. Land that was once a pond may become a forest or grassland.

Emergent plants have roots under water while part of their bodies resides above the water line.

Plant Definitions

Aquatic plant - A plant that lives in water either floating, submerged, or rooted into the pond's bed.
Carnivorous plant - A plant that traps and ingests insects for nutrition.
Deep-water plant - Aquatic plants that are submerged or rooted 12" to 36" in depth.
Invasive plant - A vigorously growing plant that will quickly overwhelm native or slower growing plants.
Marginal plant - A plant that requires permanently moist or wet conditions.
Submerged plant - A plant that remains submerged below the water line.
Terrestrial plant - A plant that is grown in normal soil conditions.

Identifying Common Aquatic Weed Section

Aquatic plants are listed in four groups according to the habitats in which they are usually found. The four groups are algae, floating weeds, emersed (above water) weeds and submersed (underwater) weeds. (Figure 1). To identify the weed in question, first decide in which group it belongs, turn to that section, and use the illustrations and descriptions to make your decision. Remember, only the more common weeds are described.

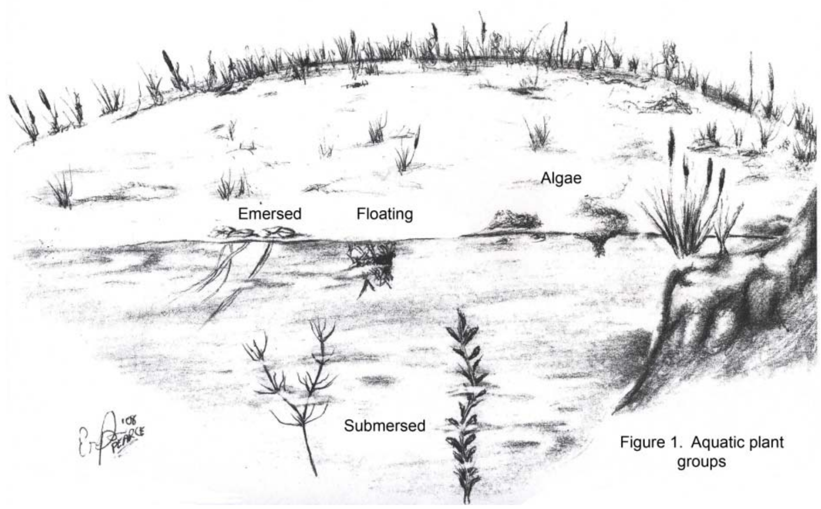


Figure 1. Aquatic plant groups

Algae

These plants occur in most waters exposed to sunlight. Shape and size vary from microscopic single-celled plants to branched-coarse plants resembling submerged aquatic weeds. Algae, unlike other aquatic plants, do not produce flowers or seeds. Based upon size and shape, algae can be divided into three groups: microscopic (planktonic) algae, filamentous algae, and stoneworts.

Microscopic Algae

Microscopic (planktonic) algae are single or multiple-celled plants that cannot be identified without the aid of magnification (Figure 2). Specific identification is usually not essential for control. Rather, it is important to recognize the plant group and not the individual species. Most of the microscopic algae respond to the same control measures. They occur in almost all ponds.

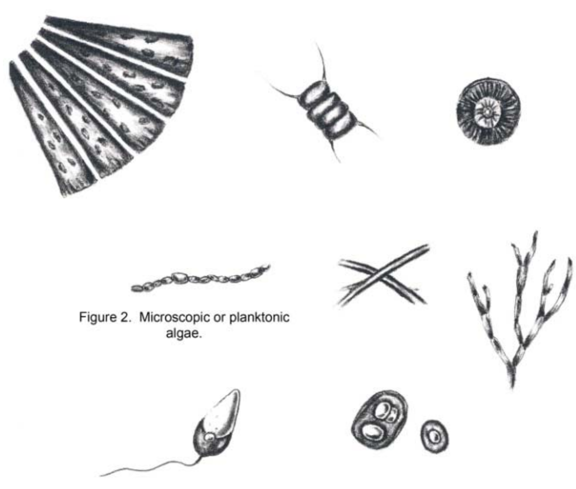


Figure 2. Microscopic or planktonic algae.

These algae are generally beneficial to ponds. They are the beginning of the food chain, converting nutrients from the water into usable food for insects and fish. Through photosynthesis, they provide dissolved oxygen, essential to life in the pond. Pond fertilization promotes the growth of microscopic algae as evidenced by the green color of the water (Figure 3). There is rarely a need to control these plants in a pond; however, excessive blooms can lead to oxygen depletion and fish kills. Excessive blooms are usually the result of over-fertilization or organic pollution.

A few species, especially some of the blue-green algae such as Microcystis, can cause fish kills and animal and human health problems. Blooms of these algae occur occasionally and are usually associated with organic pollution. Masses of these plants appear rapidly and make the water seem like a "soupy" bright green mass on the downwind side of the pond.

These plants also give off a foul sewage-like odor and can give an off-flavor to fish caught from the pond. Fish affected by the toxins of this plant act drugged and may convulse. Fish usually show these symptoms only during the daylight hours. A rapid and complete fish kill, although rare, may occur.

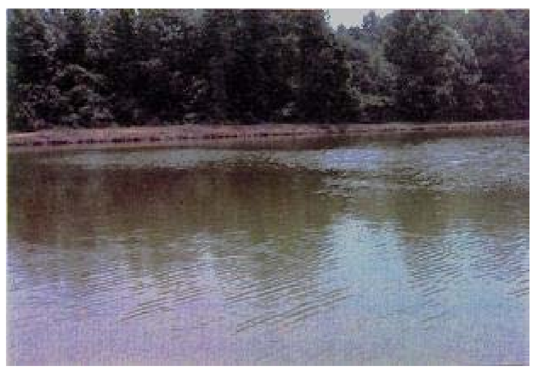


Figure 3. Microscopic (planktonic) algae.

Filamentous Algae

Unlike microscopic algae, filamentous algae are frequently a problem in pond management and are usually visible to the naked eye as a floating mat of thread-like filaments often called "pond moss" (Figure 4). They usually begin growth on the pond bottom in shallow water, later float to the surface and may completely cover the pond surface.

Figure 4. Filamentous algae.

Except for a few species, all filamentous algae control methods are similar. As with microscopic algae, it is more important to recognize the plant group and not the individual species.

One group of widespread algae which is difficult to control is *Pithophora* spp. *Pithophora* resembles a mass of wet, green wool (Figure 5).

Figure 5. *Pithophora*.

Stoneworts
This group of algae is quite often confused with underwater aquatic plants because it is attached to the pond bottom. No part of the plant extends above the water surface. Stoneworts do not produce flowers or seeds.

Chara *(Chara* spp*.)*
Chara has a distinctive musky odor when crushed (Figure 6). It is usually grey-green and has a rough texture caused by calcium deposits on the plant. This branched algae has whorled thread size "leaves" and the plant is anchored to the bottom mud. It occurs throughout the U.S. and is more commonly found in hard water areas.

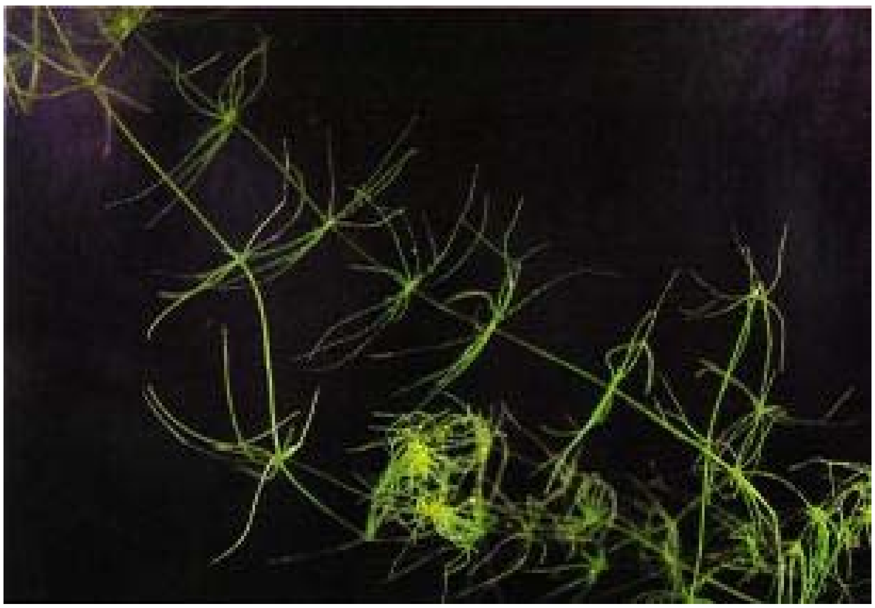


Figure 6. Chara.

Nitella (*Nitella* spp.)

Nitella is similar in appearance to Chara. However, the plant is dark green, does not have a musky odor, and does not have the texture of chara. It is more common in acid or soft water areas.

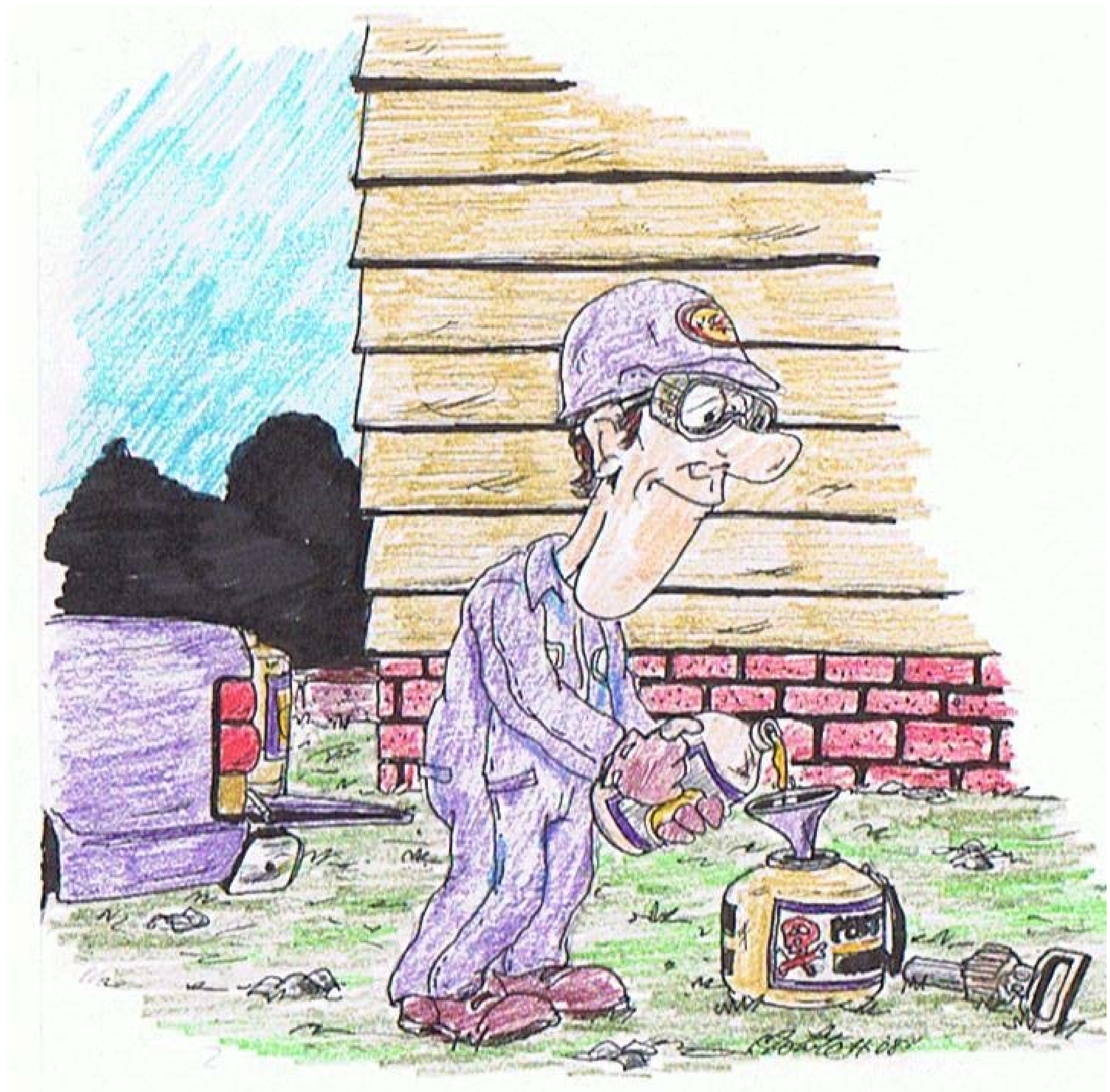
Nitella

Stoneworts are branched multicellular algae that are often confused with submerged flowering plants. However, stoneworts have no flower and will not extend above the water surface. Nitella has no odor and are soft to the touch, unlike Chara. Stoneworts are light to dark green in color with forked, bushy branches 1/16 to 1/8 inches in diameter.

Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates. These invertebrates in turn are used as food by fish and other wildlife species (e.g. amphibians, reptiles, ducks, etc.). After aquatic plants die, their decomposition by bacteria and fungi provides food for many aquatic invertebrates. Stoneworts have no known direct food value to wildlife.

Nitella can be removed by raking or seining. Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.



ALWAYS READ THE PRODUCT LABEL FOR DIRECTIONS, CURRENT RESTRICTIONS AND WARNINGS. Some considerations may include potential contamination of domestic water supplies and waiting periods for watering livestock, eating fish, swimming, and irrigation.

1. Although they provide good control when applied correctly, herbicides may also harm desirable organisms if used improperly. The decay of large amounts of dead plant material following chemical application can lower dissolved oxygen to lethal levels for fish. For this reason, it is recommended to treat only one-third of the plants at seven to ten day intervals until control is obtained. Chemical control can be very expensive and it isn't permanent; continuous re-treatment will be necessary.

Please remember that the long-term effects of most herbicides on the environment are not well known.

2. Duckweed and watermeal grow very fast. For this reason, chemical control should begin as soon as the plants appear in the spring.

Algae Control

Algae problems are usually caused by an overabundance of nutrients (nitrogen and phosphorous) in the pond. From the moment a pond is built, it becomes a settling basin for nutrients washing in from the land that drains into it (the pond's watershed). As a water body ages, the more nutrients it accumulates and the more susceptible it is to algae problems. Runoff from fertilized fields, lawns and pastures, or from feedlots, septic tanks and leach fields accelerates nutrient loading and algae growth in the pond. If the pond is old and has become shallow due to accumulation of black muck on the bottom, it may be necessary to drain, dry, and deepen the pond. Excavated material should be removed from the pond's watershed.

Planning
Establishing and maintaining a 100 foot or wider buffer strip of grass and trees around the pond's edge will help filter excess nutrients from runoff water. This combined with a 3:1 grade at the shoreline will reduce the opportunities for macrophytic algae and other rooted plants to grow to nuisance levels in the lake.

The construction of small (4-6feet in depth) silt retention ponds in the watershed will help settle out nutrients before they can enter the lake. Localized nutrient inputs from feedlots or other sources may be avoided by tiling, or by constructing a water diversion terrace below the nutrient source to direct its runoff away from the pond. Fencing livestock from the pond's edge and watering them from a tank below the dam is also a helpful protective measure.

The Natural Resource Conservation Service (NRCS) or Pesticide Regulation Agency office in your area can provide information on these and other water quality practices.

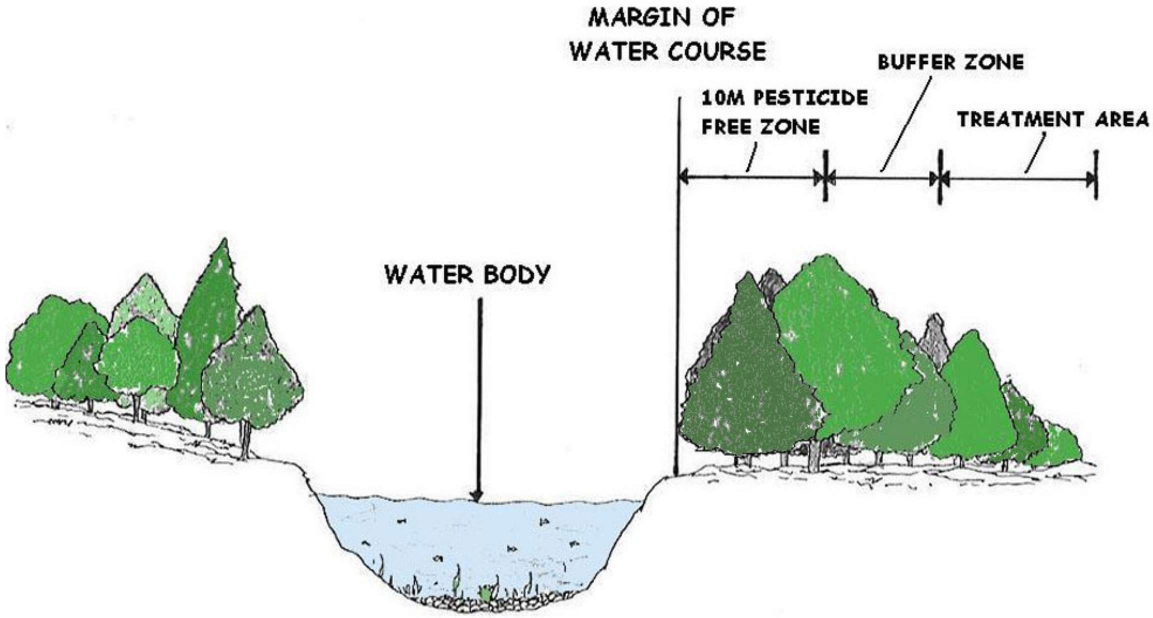
Mechanical Control
Mechanical control means removing the vegetation by hand and through the use of mechanized equipment. Mats of filamentous algae may be removed with a rake, seine, screen wire or similar devices; however, this control method is very labor intensive and provides only temporary control.

In some instances, the algae may seem to grow as fast as it is pulled out. Mechanical control is practical when used in conjunction with chemical control methods or as a maintenance treatment around swimming or fishing areas for an occasional special event.

Algae removed from the pond by mechanical means should be deposited below the pond's dam to ensure that nutrients tied up in the vegetation do not re-enter the pond.

Biological Control
Biological control is the use of biological agents (fish, pathogens, insects, plants...) to combat unwanted species, in natural, recreational, agricultural or other situations. One example of biological control is stocking grass carp (Ctenopharyngodon idella) to control aquatic vegetation. Grass carp are not very effective at controlling filamentous or macrophytic algae, except at very high densities. Grass carp do not control planktonic algae.

Chemical Control
DIRECTIONS, RESTRICTIONS AND WARNINGS
*ALWAYS READ THE PRODUCT LABEL FOR DIRECTIONS, CURRENT RESTRICTIONS AND WARNING*S. Before using chemicals, you should consider potential contamination of domestic water supplies and the waiting periods for watering livestock, eating fish, swimming, and irrigation. Algae control with chemicals works best when the water temperature is above 60° Fahrenheit and algae mats are broken up while the chemical is being applied.



Chemicals are applied to ponds and lakes to control weeds; to control fish diseases; to eliminate un-desirable fish; to control undesirable insects and aquatic invertebrates and to correct undesirable water quality problems. Pond owners are often confused by terminology, units of measure, and formulations. This confusion makes it difficult to select the right chemical, to calculate the proper amount to be applied, and to apply it to the pond in a correct and safe manner.

To avoid oxygen depletion and a possible fish kill, avoid treating when the water temperature is above 80° Fahrenheit and treat only 1/4 to 1/3 of the vegetation at a time.

Allow ten days to two weeks between consecutive treatments. Chemicals do not provide permanent control, so repeated treatments are usually necessary to keep algae at desired levels. Please remember that the long term effects of most herbicides on the environment are not well known

Currently recommended herbicides for algae control. Though these chemicals are recommended and have proven reliable, other chemicals may be suitable for aquatic weed control.

Algaecides

Cutrine Plus (Liquid)	Cutrine Plus (Granular)	Copper Sulfate (Granular)

All three are approved in most States for the control of Planktonic Algae.
All three are approved in most States for the control of Filamentous Algae.
All three are approved in most States for the control of Macrophytic Algae.

Local farm supply stores often carry, or will order, these herbicides. For alternate sources of chemicals, a copy of the product's label, or clarification of this course section, contact your Fisheries Regional office or the pesticide agency website.

Determination of Acre-Feet to Calculate Total Amount of Herbicide Needed

If the acreage of the area to be treated is known, the number of acre-feet can be determined by multiplying the number of acres by the average depth (average depth = 1/3 of the maximum depth). For example: A two acre area is to be treated and has an average depth of three feet. The volume of the water is six acre-feet.

2 acres x 3 feet (average depth) = 6 acre-feet

If the dosage of herbicide recommended is 2 gallons of herbicide per acre-foot, the total herbicide needed would be twelve gallons.

6 acre-feet x 2 gal/acre-foot = 12 gallons (total herbicide needed)

If the number of acres is not known, it can be estimated by measuring the number of square feet and dividing by 43,560. The number of square feet in many cases can be closely approximated by multiplying the average width in feet by the average length in feet. For example: A shoreline area is to be treated. The weeded area is 500 feet long and averages 10 feet wide.

The total surface area is 5,000 square feet or 0.115 acres.

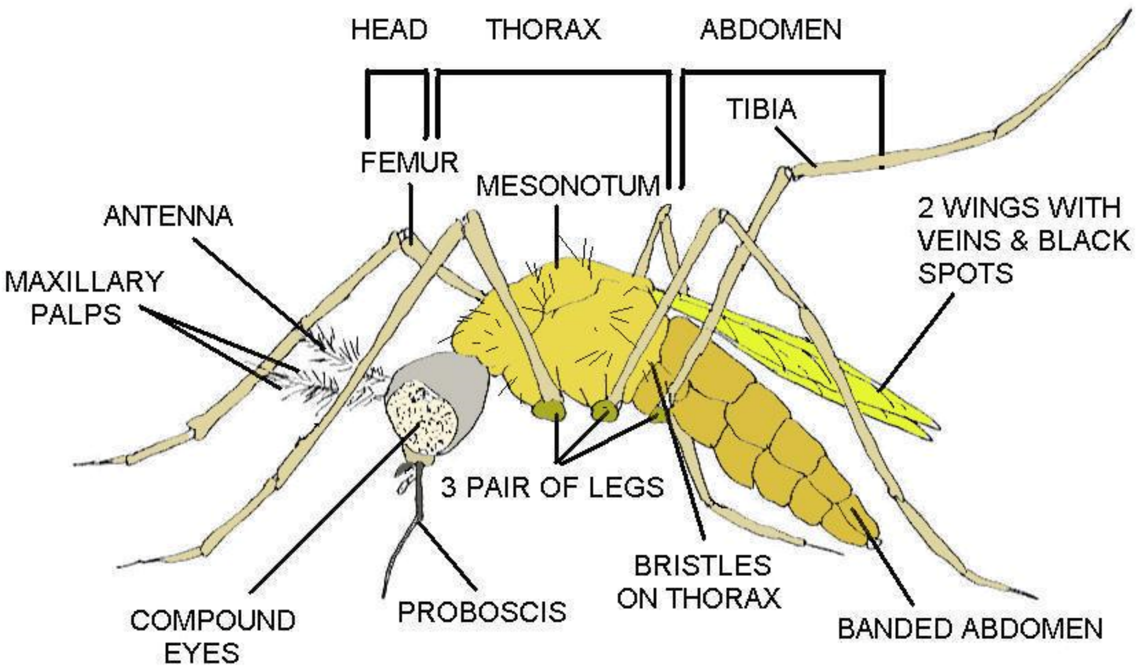
10 feet x 500 feet = 5,000 square feet
5,000 square feet .
43,560 (square feet in an acre)

The average depth of water in this shoreline area is 1 foot. The total acre-feet is 0.115.

0.115 acres x 1 foot (average depth) = 0.115 acre-feet

If we assume that 4 gal/acre-foot was the recommended dosage, then 0.46 gallons of herbicide would be needed.

4 gal/acre-foot x 0.115 (acre feet) = 0.46 gallons (total herbicide needed) = 0.115 acres



ADULT FEMALE MOSQUITO
(Anopheles Mosquito)

Floating Aquatic Weed Section

Plants in this group float in or on the water and obtain nutrients from the water rather than the soil. They are rarely attached to the pond bottom.

Duckweeds (Family-*Lemnaceae*)

Duckweeds are small floating plants which at a distance can be mistaken for algae (Figures 7, 8). Depending upon the species, duckweeds may range in size from microscopic to about 1 inch in diameter. Another plant group similar to duckweed is waterfern (Azolla spp.) Leaves of these plants are 0.1 to 0.4 inches wide and overlap one another as scales on a fish.

Figure 7. Duckweed

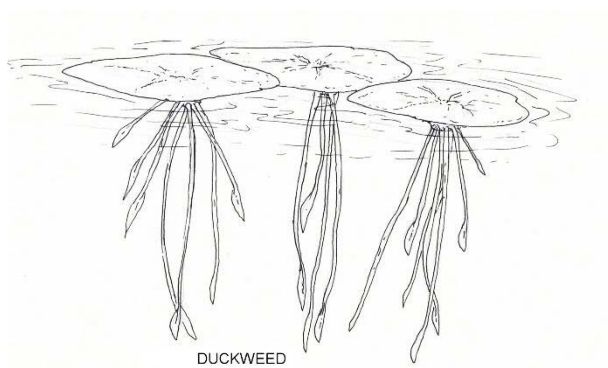


Figure 8. Duckweeds.

Duckweed and Watermeal Control

Duckweed and watermeal are fast growing aquatic plants that can sometimes reach nuisance densities in less than one month. Small amounts of these plants will not harm a good pond, but dense growths can block sunlight, reduce oxygen concentrations, and upset the natural pond balance. Mechanical, biological, and chemical control of aquatic plants are options available to the pond owner. A few duckweeds will not hurt a lagoon, but if the duckweeds become so dense that they block out the sunlight, they can be detrimental to the healthy balance that the lagoon needs to function properly.

The dense cover will reduce the light, killing the algae, thus reducing the oxygen level in the lagoon. This may cause an odor problem and the duckweed would need to be controlled. These weeds may be controlled by chemical or physical means. Chemicals work best, but either method may be short lived as one duckweed can reproduce to cover 10 square feet in one day.

Eagre - mix 2 ounces of Eagre with 2 ounces of Cide-Kick per gallon of water in a tank sprayer.

Mechanical Control

1. Seining with small mesh nets or with window-screen material can reduce coverage of free-floating plants in a small pond. Since free-floating plants reproduce so quickly, mechanical methods are only temporary solutions. However, temporary control may be all you need to enjoy a fishing trip or a swimming party.

2. Dense growth of duckweed or watermeal is usually linked to high levels of nutrients in the water. Nutrients like nitrogen and phosphorous can come from waterfowl waste, septic tank seepage, feedlot runoff, uneaten fish food, or fertilizer washed off fields, pastures or lawns.

Eliminating or diverting these nutrient sources will reduce the chance of having problems with duckweed or watermeal. If the pond is old and has become shallow due to accumulation of black muck on the bottom, it may be necessary to drain, dry, and deepen the pond. The black muck is a storehouse of nutrients that fuel the excessive growth of aquatic plants. All excavated material should be removed from the pond's watershed.

Above, we have an example of simple mechanical removal method of using a heavy rake with a rope tied to it. Toss the rake twenty feet in the pond, let the rake sink, and reel it in. Good method to remove pondweeds and nitella.

The best method for weed control is a good start or foundation. Here we have black mesh plastic that allows the water to perk in to the ground and prevent weed roots to take a firm hold, and annual draining of the pond helps kill off weeds. Problem is most of us cannot drain our pond unless there is an emergency.

Biological

Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume nitella. Grass carp stocking rates to control nitella are usually in the range of 7 to 15 per surface acre.

Tilapia will consume nitilla but are a warm water species that cannot survive in temperatures below 55° F. Therefore, tilapia usually cannot be stocked before mid-April or May and will die in November or December. Recommended stocking rates are 15 to 20 pounds of mixed sex adult Mozambique tilapia (Oreochromis mossambicus) per surface area. Tilapias are often not effective for vegetation control if the pond has a robust bass population due to intense predation.

Biological Control

The grass carp (*Ctenopharyngodon idella*), or white amur, is a plant eating Asian member of the minnow family used to control certain species of aquatic plants. Grass carp may eat some duckweed and watermeal, but these plants reproduce so quickly that they can cover a one acre pond in two months. For this reason, grass carp are generally not an effective control measure. See the Grass Carp Section in the rear for more information.

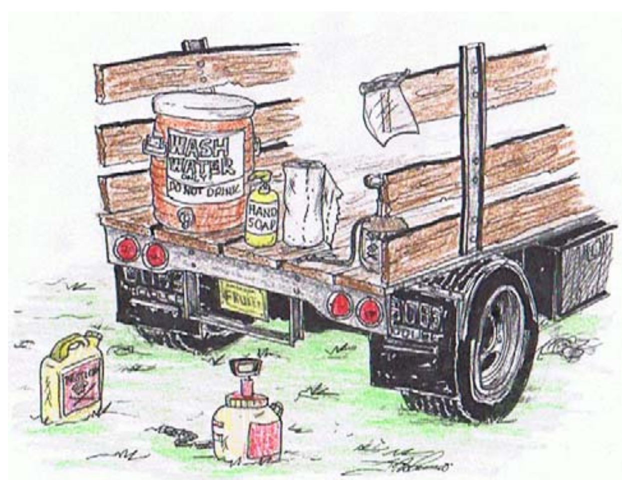
Chemical Control

1. **ALWAYS READ THE PRODUCT LABEL FOR DIRECTIONS, CURRENT RESTRICTIONS AND WARNINGS.** Some considerations may include potential contamination of domestic water supplies and waiting periods for watering livestock, eating fish, swimming, and irrigation.
2. Although they provide good control when applied correctly, herbicides may also harm desirable organisms, if used improperly. The decay of large amounts of dead plant material following chemical application can lower dissolved oxygen to lethal levels for fish. For this reason, it is recommended to treat only one-third of the plants at seven to ten day intervals until control is obtained. Chemical control can be very expensive and it isn't permanent; continuous re-treatment will be necessary.
Please remember that the long-term effects of most herbicides on the environment are not well known.
3. Duckweed and watermeal grow very fast. For this reason, chemical control should begin as soon as the plants appear in the spring.

Currently recommended herbicides for Duckweed and Watermeal control and their suggested retail prices. Though these chemicals have been tested and have proven reliable other chemicals may be suitable for aquatic weed control.

Reward and Sonar-AS Reward Weedtrine-D Cutrine Plus Liquid all four are approved for Duckweed *(Lemna spp.) See rear section form more information*
Reward and Sonar-AS Reward Weedtrine-D Cutrine Plus Liquid all four are approved for Watermeal *(Wolffia spp.) See rear section form more information*
Minimum Quantity Cutrine Plus Available 1 pint, 1 quart, 1 gal. and 1 gallon.

Pesticides are categorized according to their target use. The three major groups of pesticides are: herbicides (weed control), insecticides (insect control), and fungicides (disease control).



Plant Reproduction Key Words (See Glossary)

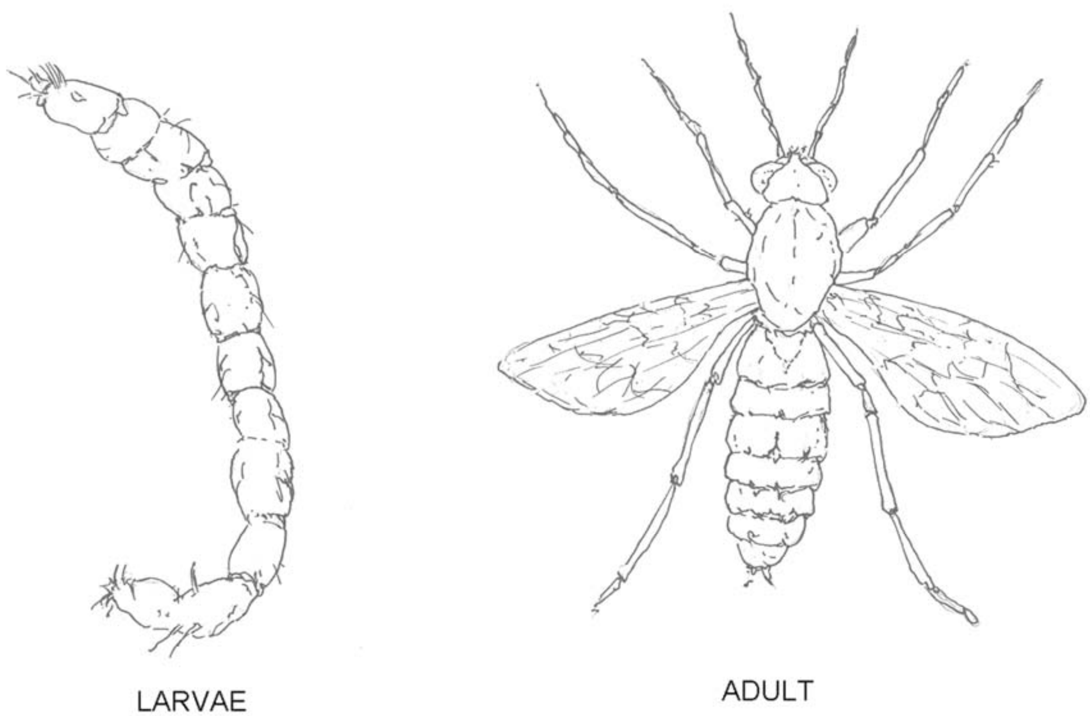
- Budding
- Fragmentation
- Rhizomes
- Tubers
- Spores
- Seeds

Herbicide Use for Duckweed and Watermeal

When using Reward, Weedtrine-D, or Reward/Cutrine Plus Liquid, the following recommendations should be followed:
1. Add a non-ionic surfactant at the rate of 3/4 ounces per gallon of water.
2. Use a fine spray when spraying the vegetation.
3. Do not treat when the pond is muddy.
4. Treat when the water surface is calm.
5. Treat any Duckweed that may be washed up on the bank.

Mix at a rate of 1/3 Cutrine Plus to 2/3 Reward. Dilute this solution at the rate of one part of mix to fourteen parts of water (one quart of solution to 3.5 gallons of water). Add 2.6 ounces of non-ionic surfactant. This quantity will treat 1/4 acre of water.

Local farm supply stores often carry, or will order, these herbicides. For alternate sources of chemicals, a copy of a product label or clarification of this course section, check with your Fisheries Regional office, Game and Fish or State Pesticide Agency office.



BITING MIDGES

Aquatic Herbicide Sources

Athea Laboratories Inc., P.O. Box 23926 Milwaukee, WI 53223.
Albaugh Inc., 1517 N. Akeny Blvd. Suite A, Ankeny, IA 50021
Applied Biochemists, 5300 W. County Line Road, 96 North, Mequon, WI 53092
Aquacide Co., 1627 9th St., White Bear Lake, MN 55110, (800)328-9350
Aquashade Inc., 6120 W. Douglas Ave., Milwaukee, WI 53218
A & V Incorporated, N62 W22632 Village Drive, Sussex, WI 53089, (205) 288-3185
Chem One Corp., 15150 Sommermeyer, Houston, TX 77041-5308
ELF Atochem North America, 2000 Market St., Philadelphia, PA 19103, (205) 288-3185
Frank Miller & Sons Inc., 13831 S. Emerald Ave., Chicago, IL 60627
Great Lakes Biochemical Co. Inc., 6120 W. Douglas Ave., Milwaukee, WI 53218
Griffin Corporation, P.O. Box 1847, Valdosta, GA 31603, (912) 244-7954
Helena Chemical Co., 6075 Poplar Ave., Suit 500, Memphis, TN 38119.
I. Schneid Inc., 1429 Fairmont Ave., N.W., Atlanta, GA 30381.
Monsanto Agricultural Company, 700 Chesterfield Parkway North, St. Louis, MO, 631987 or 800 N. Lindbergh Blvd., St. Louis, MO 63167, (919) 556-7124
NCH Corporation. 2727 Chemsearch Blvd., Irving, TX 75062.
PBI/Gordon Corporation, 1217 W. 12th Street, P.O. Box 4090, Kansas City, MO 64101, (816) 421-4070
Phelps Dodge Refining Corporation, Box 20001, El Paso TX, 79998.
Qualis Inc., 4600 Park Ave., Des Moines, IA 50321
Riverdale Chemical Co., 425 W. I94th St., Glenwood, IL 60425, (317) 780-1944
Rhone-Poulenc Ag Company, P.O. Box 12014, 2 T. W. Alexander Drive, Research Triangle Park, NC 27709, (919) 859-6070
SEPRO Corporation, 11550 N. Meridian St., Suite 200, Carmel, IN 46032, (800)419-7779
State Chemical Manufacturing Co., 3100 Hamilton Ave., Cleveland, OH 44114.
Uniroyal Chemical Co., Inc., 74 Amity Road, Bethany, CT 06524, (919) 848-9675
Zeneca Agricultural Products, Box 15458 Wilmington, DE. 19850-5458 or 1800 Concord Pike, Wilmington, DE 19897, (800) 759-2500

Water Hyacinth (*Eichhornia crassipes*)

Water hyacinths are quite variable in size, and may range from 3 to 36 inches in height (Figure 9). Flowers may be blue, violet, or white and are quite showy. They are occasionally found rooted to the bottom. The plants are a serious problem along coastal areas.

Figure 9. Water hyacinth.

Description and Variation

Water hyacinth (Eichornia crassipes) is a member of the pickerelweed family (Pontederiaceae). The plants vary in size from a few centimeters to over a meter in height. The glossy green, leathery leaf blades are up to 20 cm long and 5-15 cm wide and are attached to petioles that are often spongy-inflated. Numerous dark, branched, fibrous roots dangle in the water from the underside of the plant. The inflorescence is a loose terminal spike with showy light-blue to violet flowers (flowers are occasionally white). Each flower has 6 bluish-purple petals joined at the base to form a short tube. One petal bears a yellow spot. The fruit is a three-celled capsule containing many minute, ribbed seeds.

Economic Importance

Water hyacinth is listed as one of the most productive plants on earth and is considered the world's worst aquatic plant. It forms dense mats that interfere with navigation, recreation, irrigation, and power generation. These mats competitively exclude native submersed and floating-leaved plants. Low oxygen conditions develop beneath water hyacinth mats and the dense floating mats impede water flow and create good breeding conditions for mosquitoes. Water hyacinths are a severe environmental and economic problem in all of the gulf coast states and in many other areas of the world with a sub-tropical or tropical climate. This species has rapidly spread throughout inland and coastal freshwater bays, lakes, and marshes in the United States and in other countries.

With the increasing popularity of water gardening and home ponds, water hyacinth is now sold by many nurseries for its unusual appearance, attractive flowers, and ability to remove nutrients from the water.

Water hyacinth is thought to be cold-sensitive and unable to survive temperatures below 20°F.

Geographic Distribution
Water hyacinth originated in tropical South America, but has become naturalized in many warm areas of the world: Central America, North America (California and southern states), Africa, India, Asia, Australia, and New Zealand.

Habitat
Water hyacinths grow over a wide variety of wetland types from lakes, streams, ponds, waterways, ditches, and backwater areas. Water hyacinths obtain their nutrients directly from the water and have been used in wastewater treatment facilities. They prefer and grow most prolifically in nutrient-enriched waters. New plant populations often form from rooted parent plants, wind movements and currents help contribute to their wide distribution. Linked plants form dense rafts in the water and mud. In the Pacific Northwest, water hyacinth is planted outdoors in ponds and in aquaria, but it is not considered winter hardy, except under special conditions.

The fibrous root system of water hyacinth provides nesting habitat for invertebrates and insects. Leaf blades and petioles are occasionally used by coots. However, whatever benefits this plant provides to wildlife are greatly overshadowed by the environmental invasiveness of this noxious species.

History
It is believed that the water hyacinth was first introduced into the United States at the World's Industrial and Cotton Centennial Exposition of 1884-1885 in Louisiana. A Florida visitor to the Exposition apparently returned home with water hyacinth plants and subsequently released them into the St. Johns River. From there it spread rapidly to neighboring states.

Reproduction
Water hyacinth reproduces sexually by seeds and vegetatively by budding and stolen production. Daughter plants sprout from the stolons and doubling times have been reported of 6-18 days. The seeds can germinate in a few days or remain dormant for 15-20 years. They usually sink and remain dormant until periods of stress (droughts). Upon re-flooding, the seeds often germinate and renew the growth cycle.

Response to Herbicides
The use of herbicides to control water hyacinth is common. Westerdahl and Getsinger report excellent control of water hyacinth by the use of the aquatic herbicides 2,4-D, diquat, and a combination of diquat and complexed copper. Fair control of water hyacinth is obtained with endothall dipotassium salt, endothall dipotassium salt and complexed copper, endothall dimethylalkylamine salts, and glyphostate. Complexed copper may be allowed depending on existing sediment conditions.

Chemical
The active ingredients that have been successful in treating water hyacinth include 2,4-D (E), diquat (E), triclopyr (E), rodeo (G), and imazapyr (E). E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on water hyacinth. It is a contact algaecide and herbicide. Contact herbicides act quickly and kill all plant cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Renovate is a liquid triclopyr formulation that is effective on water hyacinth. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on water hyacinth. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of oxygen depletion after the treatment, caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Response to Mechanical Methods
Mechanical controls such as harvesting have been used for nearly 100 years in Florida, but are ineffective for large scale control, very expensive, and cannot keep pace with the rapid plant growth in large water systems.

Biocontrol Potentials
Three insects have been released for the biological control of water hyacinth. These include two weevil species (*Neochetina* spp.) and a moth (*Sameodes albiguttalis*). Unfortunately large scale reductions in water hyacinth populations did not occur. Instead insect predation reduced plant height, decreased the number of seeds produced, and decreased the seasonal growth of the plants. This, in turn, allowed better boat access into plant mats, reduced use of herbicides, and resulted in less plant problems. In Louisiana, the seasonal growth of water hyacinth was reduced from a high of over 400,000 hectares per year to lows of only about 80,000 hectares.

Hemlock

Dandelion

Coontail (*Ceratophyllum* Spp.)

The common name of this plant is very descriptive of its appearance (Figure 10). The leaves are 0.2 to 1.5 inches long in whorls on the stem, becoming more and more crowded near the tip.

Figure 10. Coontail.

Scientific Name	*Ceratophyllum demersum* L.
Common Name	Coontail
Family	Ceratophyllaceae (Coontail)
Class	Dicot
Description	Submersed free-floating (rootless) plant, highly branched, with whorled palmately dissected leaves, flowers inconspicuous, prolific seed former; evergreen perennial
US Distribution	All of North America
Worldwide Distribution	Almost global in distribution
Ecology	Submersed in 1 to 20 ft depth, wide range of water quality
Economic Importance	None
Ecological Importance	Important habitat for aquatic organisms, rarely produces a nuisance problem
Notes	Almost ubiquitous in standing water

Value - Coontail foliage is a favorite of many species of waterfowl. It is also home to many types of invertebrates, thus providing a great source of food for fish.

Nutrient Management - Overabundant plant growth is usually caused by excessive nutrients (nitrogen and phosphorous). These nutrients may come from runoff from barnyards, crop fields, septic systems, lawns, or golf courses.

Long-term control of overabundant plants is best accomplished by reducing or redirecting nutrient sources to the pond. This may be done by reducing fertilizer use near the pond, maintaining septic systems, directing nutrient-laden runoff away from the pond, or maintaining buffer strips around the pond. If you fail to address the underlying nutrient cause of plant growth, you must rely on continual removal of the plants using mechanical, biological or chemical control techniques.

Mechanical Control - Harvesting can be dangerous because this plant reproduces primarily from fragments. Attempts to harvest it may cause many fragments that may lead to new plants.

Biological Control-Grass Carp - Coontail may be controlled using grass carp.

Effective Herbicides - Aquathol-K, Hydrothol 191, Komeen, Reward, Sonar A.S. /Avast!, Sonar SRP/Avast! SRP

Bladderwort (*Utricularia* Spp.)

Bladderworts are identifiable by small bladders produced randomly on the plant (Figure 11). Leaves have many fine thread-like segments. Although bladderworts are rootless plants, stems are sometimes attached to the bottom. Flowers of many species are yellow and grow above the water surface (Figure 12).

Figure 11. Bladderwort

Figure 12. Bladderwort flower.

The bladderworts received this name because of tiny bladder-like structures on their branched underwater leaves. (The wort part of the name comes from old English, when wort meant plant).These bladders are actually small vacuum traps which catch tiny aquatic animals.

The tiny traps are oval, with a membranous door at one end. Small trigger- hairs surround the door that secretes a sweet lure. When an animal comes near the hairs, the door snaps open in a fraction of a second, sucking the animal inside the bladder. Once trapped inside, the plant absorbs the animal's nutrients using digestive juices.

Due to their ability to 'eat' animals, bladderworts can live in nutrient poor, rather acidic, boggy conditions. However, they are also common in soft water lakes. Bladderworts are free-floating plants, but usually go unnoticed due to their habit of hanging out near the bottom in shallow areas. They usually attract attention in spring and summer when they float to the surface to send up shoots of small, attractive, yellow snapdragon like flowers.

The scientific name for the bladderworts is *Utricularia*. A few species are native, the two most common being *Utricularia vulgaris* or common bladderwort, and *Utricularia minor* or lesser bladderwort. When big floating bladderwort is flowering it is easily distinguished from its native cousins by large spoke-like floats that radiate out from the base of the flower stalk. During the rest of the year, however, it can be confused with common bladderwort, both of which are rather robust and can appear almost bushy underwater.

Chemical

The active ingredients that have been successful in treating bladderwort include 2,4-D (G), diquat (G), and fluridone (G). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on bladderwort. 2,4-D compounds are systemic herbicides.

Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on bladderwort. It is a contact algaecide and herbicide. Contact herbicides act quickly and kill all plants cells that they contact.

Sonar and **Avast** are fluridone compounds and come in both liquid and granular formulations and have been effective on bladderwort. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Emersed (above water) Aquatic Weed Section

Plants in this group are rooted to the bottom but have several leaves or parts which extend above the water surface. Some of the plants in this group may grow in water 10 feet deep; most are shoreline or shallow water plants.

Waterlilies
Although not all the plants in this group are true waterlilies, they are often confused with waterlilies. This group of plants may also be called lily pad, cow lily, spatterdock and lotus. They are all rooted plants with floating leaves.

American Lotus (*Nelumbo lutea*)

American lotus leaves are large and circular, 8 to 25 inches in diameter (Figure 13). The center of the leaf is depressed, forming a cup. Leaves produced early in the season float on the water surface, and as the stem grows, the leaves become suspended above the water. The flower is pale-yellow and about 8 to 10 inches in diameter (Figure 14). Seeds are produced in a large distinctive fleshy receptacle which is yellow as the flower opens, then turns green and later, dark brown. Unlike other waterlilies, American lotus does not have a split or notched leaf.

Figure 13. American lotus.

Figure 14. American lotus flower.

Fragrant and White Waterlily (*Nymphaea* spp.*)*

Leaves of the true waterlilies are split or notched and are usually 6 to 8 inches in diameter. Fragrant waterlily (Figure 15), can be readily distinguished from white waterlily by its sweet-scented white or pink flowers. Flowers of white waterlily have little or no fragrance. Leaf veins of fragrant and white waterlilies originate from the leaf center and extend to the margin in a fan-like pattern (Figure 17).

Figure 15. Waterlily.

Figure 16. Spatterdock.

Figure 17. Waterlily leaf.

Fragrant white water lily

Flower: White, showy, fragrant, 7-20 cm wide; many petals; 4 green sepals; floats on water surface; open from mid-morning to early afternoon; throughout summer.
Leaves: Floating, 7-30 cm wide, rounded with narrow "V-shaped" split.
Other: Stalk is rounded with 4 air passages used to pump oxygen to roots.
Language of the Flower: Water lily means "coldness" or "purity of heart". The name of the water lily, *Nymphea*, is derived from the Greek word *nymphe*, meaning female deities associated with trees or water and represented as beautiful, young virgins. The virginity of the deities is the likely origin of the flower's association with coldness.

Water arum or wild calla; native perennial.

Family: Arum
Flower: Tiny; whitish or yellowish color; lack petals, in dense cluster on a fleshy spike above and hooded by a white oval bract; late May - early July.
Leaves: Basal leaves are heart-shaped, 5-10 cm long.
Fruit: Red, fleshy berries in dense heads. The fruit contains calcium oxalate crystals that are very poisonous.
Height: 10-30 cm.
Habitat: Wild calla grows near the water's edge of quiet ponds and lake margins.

Field Bindweed

Waterlettuce

Waterlettuce

Scientific Name	*Pistia stratiotes* L.
Common Name	Waterlettuce
Family	Araceae (Arum)
Class	Monocot
Description	Floating rosette species, leaves with dense hairs, vegetatively reproduces by daughter plant formation; flowers inconspicuous
US Distribution	Coastal plain from Florida to Texas
Worldwide Distribution	Tropical and subtropical regions worldwide; native to Amazon basin, South America
Ecology	Floating mat to rooted in moist soil
Economic Importance	Major nuisance species in tropical and subtropical regions
Ecological Importance	Major negative impact to subtropical and tropical aquatic ecosystems
Notes	Less cold tolerant than water hyacinth, restricted to the warmest subtropical regions

The best way to track the spread of invasive aquatic plants may be to identify the drainage basins (watersheds) they have been discovered in. Drainage maps give useful information to resource managers because drainage maps show precisely where the plants are, making it easier for managers to infer where the plants might go next, and thus where to take preventive measures.

How it got here: *Pistia stratiotes*, water lettuce, is believed by some to be a native plant and by others to be a non-native plant that arrived in the ballast of explorer's sailing ships.

Pistia stratiotes continues to be sold through aquarium supply dealers; it is not on the U.S. Federal Noxious Weed List.

Potential to spread elsewhere in U.S.:

- water lettuce is found globally in the tropics and subtropics, but its spread is limited by severe cold (Holm *et al.* 1977); its leaves re-grow after moderate freezes.
- water lettuce reproduces vegetatively and sexually; new daughter plants are formed on stolons which grow from the mother plants; seedlings are produced in mild climates (Penfound & Earle 1948).

Problems/Effects:

- *Pistia stratiotes* mats clog waterways, making boating, fishing and almost all other water activities impossible.
- Water lettuce mats degrade water quality by blocking the air-water interface and greatly reducing oxygen levels in the water, eliminating underwater animals such as fish.
- Water lettuce mats greatly reduce biological diversity: mats eliminate native submersed plants by blocking sunlight, alter emersed plant communities by pushing away and crushing them, and also alter animal communities by blocking access to the water and/or eliminating plants the animals depend on for shelter and nesting.

Control

Decades of university, state, and federal research and experience with *Pistia stratiotes* in the U.S. has led to the development of several methods to help in its management: **mechanical harvesters and chopping machines** remove water lettuce from the water and transport it to disposal on shore; **chopping machines** grind the plant into bits and spray the slurry across the water. Years of research to find **insect biocontrols** has resulted in the successful introduction of two insects which are believed to be helpful in keeping water lettuce under maintenance control in many places; however, **biocontrol fish** which are able to control submersed plants are ineffective against the floating water lettuce.

Registered aquatic herbicides do provide temporary control of water lettuce.

From the University of Florida Aquatic Weed Management Guide by V.V. Vandiver, 1999:

According to this Guide, as always, comply with federal law by following the herbicide label instructions, permissible sites, and application rates.

What can you do?

First, clean your boat before you leave the ramp! Transporting plant fragments on boats, trailers, and in live wells is the main introduction route to new lakes and rivers.

Laws and lists:

Pistia stratiotes

- is "state-listed" in Arizona, Florida, Puerto Rico and South Carolina
- is on the Florida Prohibited Plants list, Florida Department of Environmental Protection:
- is on the Florida Exotic Pest Plant Council list:
  Category I - "plants invading and disrupting native plant communities in Florida"

Chemical

The active ingredients that have been successful in treating water lettuce include endothall (G), diquat (E), rodeo (G), and imazapyr (G). E = excellent, G = good

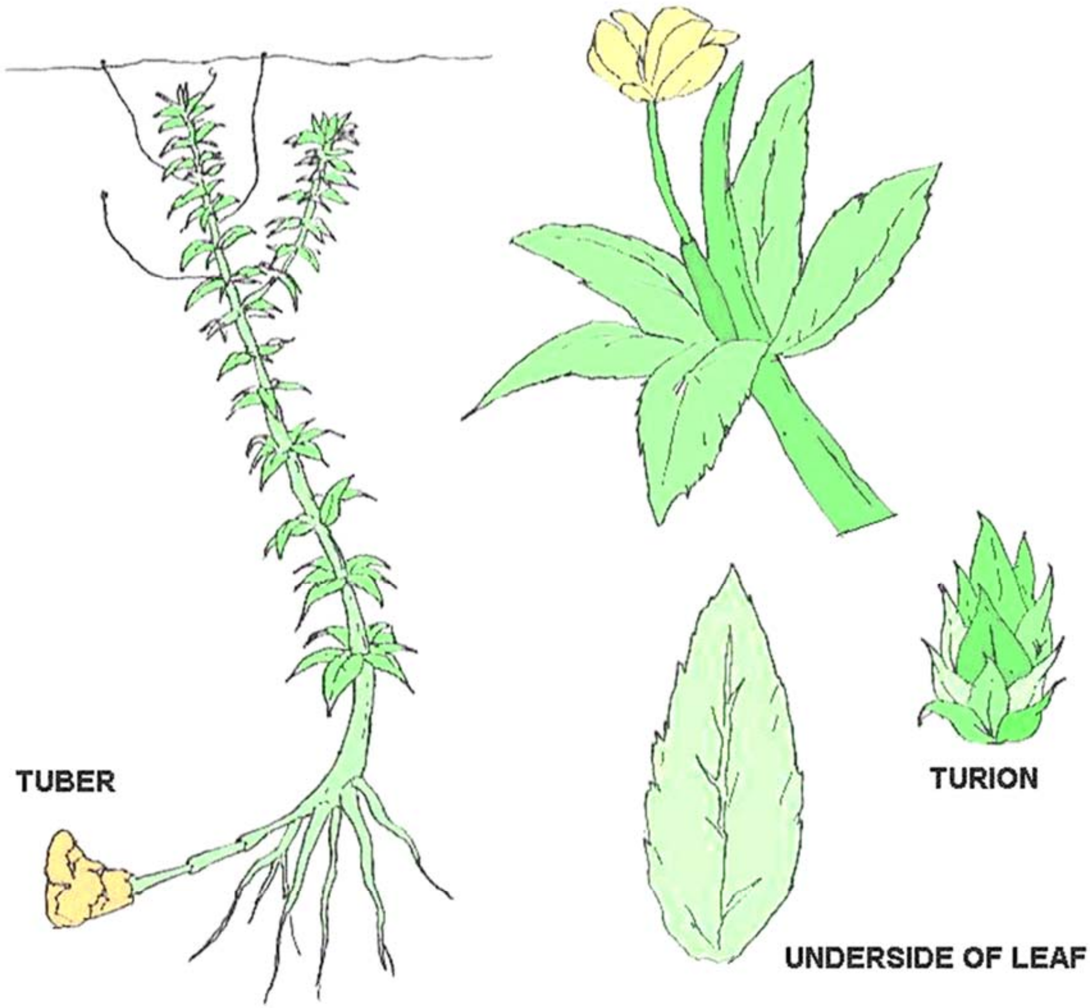
Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. The Aquathol K liquid formulation has been effective on water lettuce. Contact herbicides act quickly and kill all plant cells that they contact.

Reward is a liquid diquat formulation that has been effective on water lettuce. It is a contact algaecide and herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on water lettuce. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides, or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.



HYDRILLA

(Hydrilla vertcillata)

Spatterdock *(Nuphar luteum)*

Spatterdock is also known as pond lily, cow lily, and yellow waterlily (Figure 16). Leaves vary from nearly round to lance shaped and have a deep notch. The flower is yellow and shaped like a ball. Spatterdock can be distinguished from fragrant and white waterlily by the pattern of its leaf veins (Figures 17, 18). Spatterdock leaf veins originate from a main lateral vein and are not fan-like (Figure 18).

Figure 18. Spatterdock

Watershield (*Brasenia schreberi*)

Watershield; perennial, aquatic herb. Watershield may also be called dollar bonnet (Figure 19). The plants have floating, oval, or elliptical leaves 1 to 4 inches in size. Stems and the undersides of leaves are coated with a thick layer of gelatin-like material. This gelatinous material interferes with the uptake of some chemical treatments.

Figure 19. Watershield

Leaves: Oval and not split; 4-10 cm long; floating; underside is very slimy; stem is attached to the centre of the leaf.
Stem: Submerged, slimy, attached to the centre of the leaf.
Flowers: Dull purple-red color; 3-parted with 3 petals and 3 similar sepals; sits slightly above the water surface on stalks; June-August.
Habitat: Quiet, shallow lakes and ponds.

Floating-leaved Pondweed

Leaves: Leaf form can be quite variable; floating leaves are elliptical to oval in shape, stalked, leathery, with a waxy upper surface, many parallel veins, stalk joins at the base of each leaf; submerged leaves are bladeless, stalkless, 10-40 cm long, 1-2 mm wide, 3-5 veined.

Flowers: Small, 2-5 cm long spikes of flower clusters at stem tip; mid-summer.

Habitat: Shallow lakes and ponds, growing from organic-rich bottoms.

Similar plant: Floating-leaved pondweed is distinguished from Watershield by the junction of the stalk at the base of the leaf for floating-leaved pondweed vs. at the centre of each floating leaf for water shield.

Water Pennywort (*Hydrocotyle umbellata*)
Water pennywort is usually found growing in water less than 2 inches deep (Figure 20). Dense stands may occasionally break loose and float in deeper water. Leaves are nearly round and are 0.5 to 1.2 inches in diameter.

Figure 20. Water pennywort.

Pickerelweed (*Pontederia codata*)
Pickerelweed usually grows in shallow water areas and is more common in the coastal areas of the Southeast (Figure 23). Leaves grow in clusters 2 to 6 inches wide and 4 to 12 inches long. The flowers are violet-blue in color.

Figure 23. Pickerelweed.

Flower: Violet; funnel-like, 5-10 mm long; on stalked spike; July-September.
Leaves: Single leaf from spreading rhizomes; parallel veins, lance- to egg-shaped, 5-25 cm long, 2-15 cm wide; long sheathing stalks. Height: 30-60 cm.

Habitat: Grows in water < 1 m deep. Interest: Pickerelweed forms dense colonies. Some people suggest that the name "Pickerelweed" reflects the habitat that this plant grows in is the same as the fish known as "pickerel".

Scientific Name	*Pontederia cordata* L.
Common Name	Pickerelweed
Family	Pontederiaceae (Pickerelweed)
Class	Monocot
Description	Stout emergent with heart-shaped leaves growing from a swollen base, perennial from base, showy purple flower spike forming numerous seeds
US Distribution	Eastern North America
Worldwide Distribution	Temperate North and South America
Ecology	Shallow emergent to moist soil habitats
Economic Importance	Prominent in revegetation efforts
Ecological Importance	Hardy emergent species, good habitat for young fish, macro invertebrates; seeds a secondary food source for wildlife
Notes	Considerable variation in leaf shape; this species is being micro propagated by tissue culture techniques as IFAS

Chemical
The active ingredients that have been successful in treating pickerelweed include 2,4-D (G), triclopyr (E), diquat (G), and imazapyr (E). E = excellent, G = good
Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on pickerelweed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Renovate is a liquid triclopyr formulation that is effective on pickerelweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.
Reward is a liquid diquat formulation that has been effective on pickerelweed. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.
Habitat contains the active ingredient imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides, or phosphates.

Frogbit (*Limnobium spongia*)

Frogbit has two leaf forms. The floating or underwater leaves are heart shaped and have a deep notch (Figure 21). The underside of the leaf is thick in the center and spongy (Figure 22). The out-of-water leaves are also heart-shaped, but not as thick in the center or deeply notched, and they have a leathery feel. Frogbit may be found either growing rooted to the bottom mud in shallow water or floating on the water surface. It usually grows three inches or less in height.

Figure 21. Frogbit.

Figure 22. Frogbit--underside of floating leaf.

Chemical
The active ingredients that have been successful in treating frog's-bit include 2,4-D (E), diquat (E), imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been very effective on frog's-bit. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been very effective on frog's-bit. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation. One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Barnyard Grass

Musk Thistle

Alligatorweed (*Alternanthera philoxeroides*)

Alligator weed grows in a wide range of soil and water conditions (Figure 24). Growing plants usually form an interwoven mat which may be free floating, rooted and above water, or in a dry field. It is more common in the coastal areas. Leaves are 2 to 5 inches long, lance shaped, and have a distinct mid-rib. Flowers are white.

Figure 24. Alligatorweed.

Scientific Name:	*Alternanthera philoxeroides* (Mart.) Griseb
Common Name:	Alligatorweed
Family:	Amaranthaceae (Amaranth)
Class:	Dicot
Description:	Emersed or submersed perennial, leaves opposite and simple, flowering head of small white flowers borne in axils.
US Distribution:	Coastal states from Virginia to Texas
Worldwide Distribution:	Native to South America
Ecology:	Rooted in shallow submersed habitats to moist soil sites; may form floating mats
Economic Importance:	Major nuisance to subtropical aquatic sites and wetland areas, especially ditch and stream habitats
Ecological Importance:	Major impact on aquatic and wetland sites
Notes:	Some evidence exists for two biotypes with different responses to biocontrol and chemical controls; aquatic form has a hollow stem.

Introduction: Alligatorweed is a perennial aquatic weed commonly found in shallow waterways in the Southern States. It belongs to the pigweed family and is sometimes accidentally introduced to landscape situations with new St. Augustine sod. It can survive on terrestrial sites that remain wet or boggy.

Description: Alligatorweed has 2 to 5 inch oppositely arranged leaves that are elliptic shaped and have a distinct mid-rib. This species has white flowers. Leaves have hollow and very smooth stems. It can go unrecognized in closely mowed St. Augustine turf.

Control: The best control is to inspect sod to make sure the weed is not present. If the weed is present in large enough quantities it can compete for water and nutrients and cause sparse areas in the new turf. Under normal circumstances the weed should die out in 4-8 weeks because soil and moisture conditions in Coastal Georgia are not favorable to alligatorweed. There are no herbicides labeled for alligatorweed control in turfgrass. However, if the problem persists for more than 2 months and the turf is well established, Image can be sprayed at maximum rates. Image has good activity on pigweeds, and as alligatorweed is in the pigweed family, Image may very well control this weed. Alternatively, two-way and three-way herbicides that contain 2,4-D and dicamba may also be used. But, these products can severely injure St. Augustine grass, and should only be used at the lowest rate recommended on the label for St. Augustine grass and centipedegrass.

Chemical
The active ingredients that have been successful in treating alligatorweed include 2,4-D (G), glyphosate (G), triclopyr (E), fluridone (G), and imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on alligator weed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on alligatorweed above the water line but ineffective on plants in the water. They are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.
Renovate is a liquid triclopyr formulation that is effective on alligatorweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.
Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on alligatorweed in the water. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

Smartweed (*Polygonum* spp.)

Smartweed is a shallow water plant (Figure 25). Each joint or node is covered by a thin white to brown sheath. Leaves are linear or elliptic and alternate. Flowers are white, pink, pinkish-white or green.

Figure 25. Smartweed.

Flower: Tiny, pink flowers; 4 mm long; slender, spike-like clusters 4-17 cm long; 5 parted calyx, lacks petals; July-September.
Leaves: Lanceolate, tapering at both ends; 5-20 cm long; may be floating; may encircle the stem where leaf joins stem.
Height: 60-90 cm.

Biological
There is no known biological control for smartweed, although goats are known to forage on many types of emergent vegetation.

Chemical
The active ingredients that have been successful in treating smartweed include 2,4-D (E), triclopyr (G), and glyphosate (E). E = excellent, G = good
Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on smartweed. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.
Renovate is a liquid triclopyr formulation that is effective on smartweed. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.
Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on smartweed. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Pink Smartweed (*Polygonum bicorne* Raf.)

Erect, climbing plant, up to 2 meters tall, with clusters of small pink flowers on a slender spike. Member of the Buckwheat Family (Polygonaceae) along with Knotweed and Buckwheat. Seen here growing in shallow water with water willow; Lake Kahola, east-central Kansas. Based on Freeman and Schofield (1991) and Zim and Martin (1950).

Arrowhead (*Sagittaria* Spp.)

Arrowhead is a shallow water plant (Figure 26). Leaf shapes are highly variable; however, they are usually in the shape of an "arrowhead". Leaves are usually above the water, but they may be under the water or floating.

Figure 26. Arrowhead.

Water Primrose (*Jussiaea* Spp.--*Ludwigia* Spp.)

Water primrose grows along the shoreline and in shallow water areas (Figure 27). Leaves are light green, about 3 inches long, and lance-or-oval shaped. Stems may appear reddish-green. Flowers are bright yellow, about one inch in diameter and have 5 petals.

Figure 27. Water primrose.

Biological
There is no known biological control for water primrose, although goats are known to forage on many types of emergent vegetation.

Chemical
The active ingredients that have been successful in treating water primrose include 2,4-D (E), diquat (E), triclopyr (E), glyphosate (E), and imazapyr (E). E = excellent, G = good

Navigate and **Aqua-Kleen** are 2,4-D compounds that have been effective on water primrose. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on water primrose. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Renovate is a liquid triclopyr formulation that is effective on water primrose. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat**are liquid glyphosate formulations and have been effective on water primrose. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

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Cattails (*Typha* Spp.)

Cattails usually grow along the shoreline and are sometimes found in water 3 to 4 feet deep (Figure 28). Plants may attain a height of 6 to 8 feet. Leaves are about 1 inch wide, and ribbon shaped flowers are produced on the end of stalks in cylindrical clusters; hence the name "cattail."

Figure 28. Cattail.

Scientific Name	*Typha* spp. L. (*T. latifolia, T. glauca, T. angustifolia, T. domingensis*)
Common Name	Cattail
Family	Typhaceae (Cattail)
Class	Monocot
Description	Primarily emergent from subterranean rhizome, leaves long and strap-like flowers inconspicuous in floral head, with sexes separate, wind pollinated
US Distribution	Throughout US and southern Canada
Worldwide Distribution	Temperate North America, Europe, and Asia
Ecology	Emergent in up to 3 ft. depth, to moist soil
Economic Importance	May become a nuisance, also as a roost for blackbird swarms

Ecological Importance	Can be good cover for wildlife, food for muskrats, etc.; may out-compete other natives in some situations (prairie pothole region)
Notes	Some of these species hybridize; some evidence that *T. latifolia* is not native

Cattails

The common cattail is a native, opportunistic North American wetland species. The narrow-leaved cattail is possibly an exotic or hybrid. Cattails can be found in damp soil or shallow water where sufficient nutrients are available. It is a common site along expressways, in artificial ditches and shallow ponds, at the edges of calm waters, in consistently damp patches of rural and suburban yards, and in freshwater marshes. This prolific plant plays an important role as a source of food and shelter for different marsh-dwelling animals, especially when cattails form large stands on relatively open, wet soils abutted by water.

The velvety brown flower head and long, graceful lanceolate leaves of the cattail are a common site throughout wetlands. The flower head, shaped like an elongate cylinder, is a compact spike at the terminal end of a stem 1-3 meters tall. The flower spike is divided into two readily distinguishable parts: pistillate flowers form the conspicuous brown club located below the yellow spire of staminate flowers.

The leaves originate at the base of the stem and spread outward as they rise into the air. Below ground, starchy rhizomes anchor the plant to the soil. If the plants are growing in a colony, their rhizomes may become intertwined and form a dense mat.

Of the two commonly found species of cattail that exist, common cattail is taller and generally more robust than the narrow-leaved variety. Observation of the flower spike also helps distinguish the two species. The pistillate and staminate flowers of the common cattail emerge in direct contact with one another, with no gap separating the male and female flower parts; on the flower spike of the narrow-leaved cattail, the pistillate and staminate flowers are separated by a gap 2-10 centimeters in length.

Cattails reproduce sexually by seed and vegetatively by the production of rhizomes. The flower head of the parent plant can produce 250,000 seeds, which are then wind-dispersed. Seeds remain viable in the seed bank for up to 100 years. Cattail seeds prefer freshwater, and will not germinate unless saturated in at least 0.5-1 inch of water. Sunlight affects germination rates; seeds will remain quiescent if the area does not receive the proper amount of sunlight.

Cattails also reproduce asexually by rhizomes. During the first summer of vegetative propagation, rhizomes grow about two feet in length. New shoots emerge at the rhizome around mid-summer. Cattails can quickly dominate a wetland plant community and produce monotypic stands that reduce the overall habitat value.

Control Methods

The acreage of cattail-dominated wetlands in the United States has increased drastically since the early twentieth century due to changes in hydrology and land use. The optimal control technique for a given site will depend on the hydrologic state of the site, the size of the area to be managed, and whether the manager is able to manipulate water levels.

Narrow-leaved Cattails

Mechanical Control:

Water Level: The control of cattails by the manipulation of water level must be timed to the annual cycle of carbohydrate storage. Special leaf and stem cells called aerenchyma provide air passage from both living and dead leaves to the rhizomes. Removing dead leaves and submerging the shoots in early spring will strain the plant and eventually kill it. The depth of water necessary to kill the plants depends on temperature; the quantity of starch the plant stored the previous year, and the general vigor of the plants. Therefore, no minimum water depth can be prescribed, but generally, a water level maintained at 3-4 feet above the tops of existing spring shoots will retard growth.

It is critical to remember that even if dead leaves from the previous year are completely removed, aerobic conditions will be restored to the rhizome as soon as the new growing shoot penetrates the water surface.

Even if water levels are sustained at only a few inches above the tops of the growing shoots, oxygen is prevented from reaching the rhizomes. The use of water is most efficient if the water level is raised progressively, so that all plant parts remain submerged by no more than a few inches. Water levels in the range of four to five feet also favor the wintertime survival of muskrats in flooded areas. Population levels of ten muskrats per acre, when combined with high springtime water levels, can nearly eliminate the emergence of cattails within a span of two years.

Cutting, Crushing, Shearing, and Discing

Starch reserves in the rhizomes are at their minimum in late spring when the pistillate spike of the cattail is lime green and the staminate spike is dark green. This is the best time to employ cutting, crushing, shearing, and/or disking to eliminate cattail colonies, because all these methods impede starch storage during the growing season. The methods of control work best if employed during a three-week time window beginning one week before and ending one week after the staminate spike has emerged.

Deep discing can retard shoot formation and damage the rhizomes, but should be used in combination with water-level control and the prevention of seed establishment to effectively hinder the re-emergence of cattails. Discing combined with continued drying and freezing in fall decreases plant survival; if a wetland can be kept dry enough to repetitively disk for 2-3 successive seasons, cattails can be eliminated or their stem densities severely reduced.

However, disking has some major drawbacks: the equipment and personnel needed to carry out this method of control are costly, and will seriously disturb the site. This will likely result in the loss of other native plants in the area as well.

Cutting, crushing, shearing, or disking severs the aerenchyma link that provides oxygen between the rhizomes and leaves of cattails during dormancy. These techniques must be combined with high springtime water levels in order to effectively retard plant growth.

Cattails can be cut with a rotary mower or sheared with a front-end loader on a tractor when equipment can be driven on ice, but airborne seeds may clog equipment. High water levels must be maintained throughout the spring and early summer.

Bulldozer
Bulldozers can effectively remove plants from a marsh, but will generally drastically disturb the wetland. Permits must be obtained before clearing a marsh with heavy equipment. A bulldozer or other machinery is the only viable method that will remove floating cattail mats, but these removal methods are also costly, and effects may be short-lived. If the seed bank of the marsh is dominated by cattails, a new colony of the hardy plants may spring up after the next drawdown of the marsh; other undesirable plants could also take the place of the cattails in the marsh.

Grazing
Grazing by cows, geese, muskrats, and other animals can be an effective method of cattail management. Grazing on seedlings and young cattails without extensive rhizomes can reduce the stem density of the colony. For mature plants, grazing combined with water-level management reduces survival rates. To maximize the impact of grazing, it should be heaviest during the three-week window of time when the flower spikes are emerging.

Prescribed Burning
Most cattail marshes must be burned in winter or before significant growth has occurred in spring; these are generally the only times when fuels are dry enough to carry a fire, although frozen ground or saturated soil may impede the fire's progress through the cattail duff. Fire is most effective as a control method when followed by naturally or artificially high water levels in the spring to smother residual stalks.

Drought
During times of drought, cattail stands overlying well-developed peat soils can be eliminated by burning. Because such fires burn peat, the ability to smother the fire by re-flooding the marsh must exist before a prescribed burn can be implemented. Peat fires can also cause undesirable changes in the marsh environment, such as destruction of the seed bank, loss of peat, and air pollution.

Chemical Control
Application in mid to late summer enhances the effectiveness of translocated herbicides, although the herbicides will have little effect on seed production during the year of application. A hemi-marsh may be created if some cattails survive, although the ability of the marsh to persist in this condition depends on the manipulation of water levels. Water level control to minimize recruitment from the seed bank must be used to ensure cattails will not return once reduced by herbicides.

Herbicides can be detrimental to wetlands habitats--be sure to use herbicides that readily break down in water, soil, or substrate, such as glyphosate formulated for use over water. Boom or wick applications by ground or air boat are best for small areas where pesticide drift is a concern. Aerial applications may be used on large areas. Herbicidal control of cattails may be costly, although actual application of the herbicide usually represents a small fraction of this cost.

One area manager found that an aerial application of glyphosate during August was effective in controlling cattails, dogwood, and willow, but quite costly at $110/acre. Due to the possibility of fish contamination, notice must be posted before spraying, and can be done only by a person licensed to apply herbicides.

The active ingredients that have been successful in treating cattails include diquat (G), glyphosate (E), and imazapyr (E). n E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on cattails. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact. A non-ionic aquatically registered surfactant (see the label) will have to be added to the Reward solution for good results.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on cattails. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment, caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Control of Cattails and Duckweed in Wastewater Lagoons

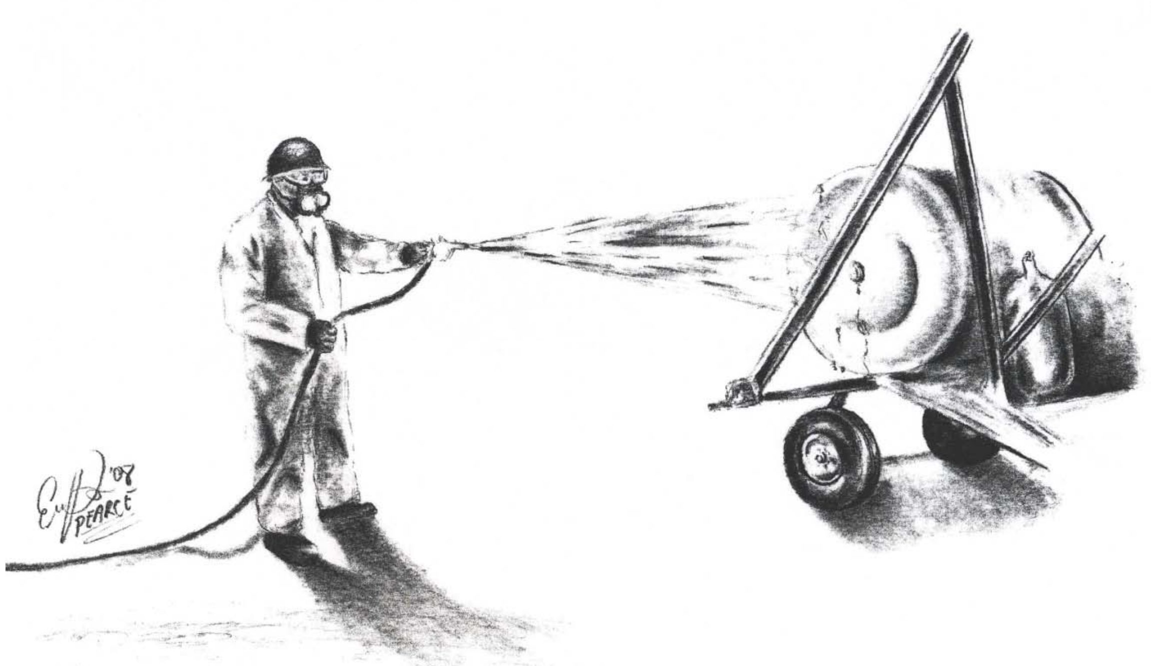
A properly functioning lagoon should be maintained on a regular basis. This includes keeping the berms free of trees and weeds and ensuring that no animals are burrowing in the berms. The water of the lagoon should be a green color, due to the algae present, and be reasonably free of cattails.

The lagoon should have little to no odor. Cattail and duckweed are two weeds that tend to multiply rapidly, thrive in the sewage environment, and take over the entire lagoon if allowed.

A few duckweeds will not hurt a lagoon, but if the duckweeds become so dense that they block out the sunlight, they can be detrimental to the healthy balance that the lagoon needs to function properly. The dense cover will reduce the light, killing the algae, thus reducing the oxygen level in the lagoon.

This may cause an odor problem so the duckweed needs to be controlled. These weeds may be controlled by chemical or physical means.

Chemicals work best, but either method may be short lived as one duckweed can reproduce to cover 10 square feet in one day.



Purple Loosestrife

Purple Loosestrife

Scientific Name	*Lythrum salicaria* L.
Common Name	Purple Loosestrife
Family	Lythraceae (Loosestrife)
Class	Dicot
Description	Erect herbaceous perennial, overwinters by root crown, showy purple flowers, prolific seed production
US Distribution	Northern two-thirds of US and southern Canada
Worldwide Distribution	Temperate northern hemisphere and Australia; not a nuisance in Europe; native to Europe
Ecology	Moist soil to emergent shallow water areas, may even grow in moist upland areas
Economic Importance	Imported for honey production and as an ornamental
Ecological Importance	Major negative impact on wetlands in North America; reduces waterfowl food and nesting
Notes	Seedlings established best on moist soil or mudflats

What is it?

Purple Loosestrife (*Lythrum salicaria*) is a perennial wetland herb that grows in sunny wetlands, ditches, around farm ponds and in other disturbed habitat. It is native to Europe and was accidentally introduced into North America in the mid-1800s. Because it has no natural enemies here, it has spread aggressively into wetlands throughout the northeast and the upper Midwest. In fact, it is known to have occurred in over 40 of 48 contiguous states

Purple Loosestrife has showy purple spikes of flowers, making it an attractive garden flower. The use of purple loosestrife in landscape plantings and flower gardens has added to its spread in the United States. Seven hybrids that are considered non-aggressive are now commercially available. They are: Morden Pink, The Rocket, Rose Queen, Dropmore Purple, Columbia Pink, Morden Rose and Morden Gleam.

Why Is It A Problem?

Purple Loosestrife reproduces prolifically by cuttings and offshoots as well as by seeds. A single plant may produce up to 300,000 seeds, which are carried by wind, water and animals. Purple Loosestrife is so aggressive that it crowds out the native plants that are used by wildlife for food and shelter. Purple Loosestrife has almost no wildlife food and shelter value, and so where it invades, valuable wildlife habitat is destroyed. Once established it can destroy marshes and wet prairies and choke waterways.

Where and When to Look

It formerly occurred primarily in the northeast quarter of the country, but now might be found anywhere. The brilliant purple spikes are showy from late June or early July through late August. Look for it in marshes, wet prairies, along streams, around farm ponds, and in moist fields, pastures and roadside ditches.

How to Control It

Purple Loosestrife spreads rapidly by the very numerous seeds (up to 300,000 per plant) produced annually. For this reason it is very important to locate and eradicate the first plants to invade a wetland basin or habitat. An ounce of prevention is worth many, many pounds of cure later on.

Small infestations of up to 100 plants are best eliminated by hand pulling. Pull all or as much as possible of the root system out. If the plants are simply broken off at the soil surface, the "root crown" will sprout new stems. Pull plants early in the flowering season if possible to avoid scattering seeds in the removal process.

Remove all stems from the wetland area, as discarded stems will sprout and create new plants. Clusters in excess of 100 plants, up to three acres, and plants too large to pull out, are best controlled by herbicides. Currently, Loosestrife can be controlled with Roundup on terrestrial sites and Rodeo in wetlands and over water. These are U.S. Environmental Protection Agency registered herbicides that should be applied by licensed herbicide applicators following label instructions.

Larger infestations are not presently controllable but may be contained in some situations by pulling and/or herbicide treatment of individual plants as they spread around the periphery of dense stands. Effective control of large infestations is dependent on future research. Present action is aimed at containing the spread of this weed.

Sedges and Rushes Section

There are many species of rushes and sedges in the U.S. Few of them are ever a problem in pond management. Examples of some members of this family are illustrated (Figure 29).

Figure 29. Rushes.

One species, slender spikerush (Eleocharis acicularis), is a major problem in some ponds (Figure 30). Slender spikerush plants are small and hair-like varying from 2 to 6 inches long. Leaves arise from the base of the plant in tufts. Plants grow along the bottom, but may break away and form living floating mats.

Figure 30. Slender spikerush.

Spike Rushes (*Eleocharis spp.*)

Grass-like plants that grow in clumps from 10 cm to 1½ m tall, depending on species. Characterized by leafless stems, each of which has a small fruiting spike at the top. Spike rushes are quite common in and diagnostic of wetland environments in temperate regions around the world. They provide shelter for fish, amphibians, and insects, and are a food resource for many wetland birds and mammals. Pictured here is the **Blunt Spike Rush** (*Eleocharis obtusa*) growing in a shallow stream channel.

Water Willow (*Justicia americana*)

Erect stems with opposed, willow-shaped leaves, for which the plant is named. Small, orchid-like, white flowers bloom on long-stemmed spikes. Roots are usually submerged in shallow water along stream or pond margins. Greatest value of water willow is for stabilizing streambeds and shorelines.

Bulrushes (*Scirpus spp.*)

Bulrushes, among the most beneficial emergent wetland plants, are actually members of the sedge family. They are found in all types of fresh and alkali wetland settings--marshes, river banks, and lake shorelines. They may form dense thickets along the margins of water bodies. The seeds are particularly valuable for ducks; bulrush provides nesting habitat, and it binds wet soils quite effectively. Also known as tule or club rush. **Great Bulrush** (*Scirpus validus*).

Mechanical/Physical
Bulrushes can be cut and the rhizomes can be dug up but physical control is difficult because it can reestablish from seeds and remaining rhizomes. Frequent mowing has been somewhat effective in the control of bulrush.There is no known biological control for bulrush, although goats are known to forage on many types of emergent vegetation.

Chemical
The active ingredient that has been most successful in treating bull rushes is glyphosate. **Rodeo**, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on bulrushes. They are a broad spectrum, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Woody Plant Section

There are a large number of woody plants that may grow along the edges of a pond which are potential problems to pond management. There are 4 species in the U.S. that are a common problem; buttonbush (Cephalanthus occidentalis), willows (Salix spp.), salt cedar (Tamarix spp.) and alders (Alnus spp.).

Buttonbush

Buttonbush is a small to medium sized shrub (Figure 31). The flowering heads of this shrub resemble buttons at a distance. Leaves are whorled, 2 to 6 inches long, elliptic or oval shaped, and coarse textured.

Figure 31. Buttonbush.

Willows

Willows are large shrubs or trees with alternate leaves which are several times longer than wide (Figure 32). The leaves are usually toothed on the margin. The wood is soft and light, and the bark is aromatic but has a bitter taste.

Figure 32. Willow.

Alders

Alders are large shrubs or small trees whose alternate leaves are coarse textured, heavy veined, and toothed (Figure 33). Flowers occur in clusters and resemble small pine cones when mature.

Figure 33. Alder.

The best-known species in Europe is the Common or Black Alder (A. glutinosa), native to most of Europe and widely introduced elsewhere. The largest species is Red Alder (A. rubra), reaching 35 m (the tallest is 32 m) on the west coast of North America, with Black Alder and Italian Alder (A. cordata) both reaching about 30 m. By contrast, the widespread Green Alder (A. viridis) is rarely more than a 5 m shrub.

Alders establish symbioses with the nitrogen-fixing Actinobacteria Frankiella alni. This bacteria converts atmospheric nitrogen into soil-soluble nitrates which can be utilised by the alder, and favorably enhances the soil fertility generally. Alders benefit other plants growing near them by taking nitrogen out of the air and depositing it in the soil in usable form; fallen alder leaves make very rich compost.

Alders are sturdy and fast-growing, even in acidic and damaged sites such as burned areas and mining sites. Italian Alder is particularly useful on dry, infertile sites. Alders can be used as a producer of simple bio-mass, growing quickly in harsh environments.

Alder catkins are one of the first sources of pollen for bee species, especially honeybees, which use it for spring buildup. Alders are also used as a food plant by some Lepidoptera (butterfly and moth) species, see list of Lepidoptera that feed on alders. Alders are also grown in gardens, and are sometimes made into bonsai.

Alder is a preferred wood for charcoal making, formerly used in the manufacture of gunpowder, or for smelting metal ores, now used primarily for cooking. The wood is also traditionally used for smoking fish and meat, though this usage has often been replaced by other woods such as oak and hickory.

Tamarisk Saltcedar (*Tamarix spp)*

Saltcedar

This term includes *Tamarix* spp., especially *T. ramosissima* (Ledeb.), which is generally (but incorrectly) known as *T. pentandra* (Baum 1978). Saltcedar is a native of Eurasia and Africa, was introduced into the United States as an ornamental shrub in the early 1800s, and has now spread throughout the inter-mountain region of the western United States (Carman and Brotherson 1982). Saltcedar is considered beneficial in that it provides good nesting habitat for wildlife (including doves) and is an excellent source of nectar for honeybees in Arizona and New Mexico (Deloach 1989).

Saltcedar is a deciduous shrub or small tree growing to 12'-15' in height. Slender, long gray-green branches are spreading or upright, often forming dense thickets. Scalelike leaves are gray-green, alternately arranged, narrow, pointed, about 1/16" long, and overlap one another on the stems. Active growth occurs from early or mid-spring to fall, when leaves drop.

Leaves often become encrusted with salt secretions. Branches take on a brown-purple color as they age. Bark is reddish-brown and smooth on young branches, becoming ridged and furrowed on older limbs. Large numbers of pink to white flowers, about 1/16" across, appear in a dense mass on 1/2"- 2" spikes at branch tips from March to September.

Flowers are pollinated by bees and other insects and produce greenish-yellow to pinkish-red capsules, 1/8"-1/5" long, which split into three to five parts on maturity. Seeds are 1/25" long, with a tuft of fine hairs at one end. The number of seeds per capsule is not constant. Seeds are dispersed by wind to new locations.

Seedlings require extended periods of soil saturation for establishment. Large bush or small coniferous tree, up to 4 meters tall, with attractive pink flowers.

Saltcedar originated in Eurasia and Africa and was brought to North America as an ornamental shrub. During the 1930s, it was planted widely in the Great Plains and American West in windbreaks to control soil erosion. Since then, saltcedar has become an invasive plant that grows in dense thickets along streams, rivers and wetlands. It has displaced native vegetation, changed wildlife habitat, and increased fire risk.

Saltcedar occurs in moist rangeland and pastures, bottomlands, banks, and drainage washes of natural or artificial waterbodies, and in other areas where seedlings can be exposed to extended periods of saturated soil conditions for establishment. Saltcedar can grow on soils with up to 15,000 ppm soluble salt. Established plants have long roots that can tap deep water tables. Furthermore, saltcedar has the highest known evapotranspiration rate of any desert phreatophyte (Carman and Brotherson 1982), which may result in water depletion from the underlying soil.

Among the serious direct impacts of this species are the displacement of native range plants by its aggressive growth, the possibly serious depletion of ground water due to its rapid evapotranspiration rate, increased deposition of sediments in tamarisk- infested streams, and the blockage of streams and artificial water channels by dense clumps of saltcedar growth, which can promote flooding during periods of heavy rain.

Grass Section

There are many grass species that can be a management problem in ponds. Maidencane (Panicum hemitomon) and southern watergrass (Hydrochloa caroliniensis) are probably the most common and difficult to control.

Maidencane

The stalks are long and narrow (Figure 34). Stems may be 3 to 8 feet tall growing in up to 2 feet of water. Leaf blades are 4 to 10 inches long and 0.2 to 0.6 inches wide. Leaves are rough on the upper surface and smooth on the under surface.

Figure 34. Maidencane.

Control Options

Mechanical/Physical

Maidencane can be cut and the rhizomes can be dug up, but physical control is difficult because it can reestablish from seed and remaining rhizomes.

Biological

There is no known biological control for maidencane, although goats are known to forage on many types of emergent vegetation.

Chemical

The only active ingredient that has been very successful in treating maidencane is glyphosate.

Rodeo, **Aquamaster**, **Eraser AQ**, **Touchdown Pro**, and **AquaNeat** are liquid glyphosate formulations and have been effective on maidencane. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Prairie Cordgrass (*Spartina pectinata*)

Prairie cordgrass (or sloughgrass) forms a thick sod in low, wet soils. It grows up to 2 meters tall and can be cut for hay several times during the summer (Van Bruggen 1992). Prairie cordgrass tolerates high salinity levels, so it is common in salty wetland habitats. Early spring growth in a salt marsh at Quivira National Wildlife Refuge, south-central Kansas.

Wild Rice

Scientific Name	*Zizania aquatica* L.
Common Name	Wild Rice
Family	Poaceae (Grass)
Class	Monocot
Description	True annual, overwinters as seed, tall emergent (10 ft.) with long tapering leaves, panicle is large loose head, prolific seed producer
US Distribution	Northern North America; other species throughout US
Worldwide Distribution	Circumboreal

Ecology	Shallow emergent areas, requires water for seed germination
Economic Importance	Important crop for First nation; commercially produced; tropical rice (*Oryza sativa*) is possibly the most important crop worldwide, and is grown originally as an aquatic
Ecological Importance	Highly significant food source for waterfowl
Notes	Native Texas wild rice (*Z. texana*) is on endangered species list

Southern Watergrass

Stems are branched and the underwater portion is usually leafless (Figure 35). Floating leaf blades are 2 to 4 inches long and 1/8 to ¼ inch wide.

Figure 35. Southern Watergrass.

Southern Watergrass
Control Options
Mechanical/Physical - Southern watergrass can be cut and the roots can be dug up but physical control is difficult because it can reestablish from seeds and remaining roots.
Biological - There is no known biological control for southern watergrass, although goats are known to forage on many types of emergent vegetation.
Chemical - The active ingredients that have been successful in treating southern watergrass include glyphosate (*E*) and fluridone (*G*). *E = excellent, G = good*

Rodeo**, **Aquamaster**, and **Aquaneat are liquid glyphosate formulations and have been effective on southern watergrass. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will have to be added to the glyphosate solution for good results.

Sonar and ***Avast*** are fluridone compounds, come in both liquid and granular formulations, and have been effective on southern watergrass. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

One common problem in using aquatic herbicides is determining area and/or volume of the pond or area to be treated. Always read and follow all label directions. Check label for specific water use restrictions.

Cultivation Options

Southern watergrass can be propagated by transplanting whole plants into moist soils during the winter or early spring.

Submersed (underwater) Aquatic Weed Section

Plants in this group grow under and up to the water surface. Some submersed plants have seed heads which extend above the surface and may be confused with emersed plants. However, unlike emersed plants, most submersed weeds are dependent upon water for support. When submersed plants are removed from water, they may be limp and unable to support themselves in an upright position. Submersed weeds can be the most difficult group to identify and control, yet are some of the most common weeds interfering with pond uses.

Naiads (*Najas* Spp.)

Naiads are perennial freshwater plants with floating or submerged leaves, or both. They grow in rice fields and other areas where standing water persists from early spring into summer. On mature plants, leaves encircle the stem in whorls of three. Leaves are very narrow, 0.01 to 0.1 inch (0.25 - 2.5 mm) wide and taper at the tips. Stems are 10 to 25 inches (25 to 62.5 cm) long and may branch at the nodes. Tiny axillary flowers emerge from the sheath at the base of the leaf. Plants propagate from seeds or from stems. This group of plants, also known as bushy pondweed is very common. The margins of the leaves have a "sawtooth" appearance, but in some species these teeth are barely visible without magnification. Leaf size and appearance can vary with different species from a small, thread-like (0.4-1.5 inches long and 0.1 inches wide) shape to a broader, saw-like shape (0.4-1.5 inches long and 0.6-2.0 inches wide). The leaves occur opposite and some species have three leaves in each whorl. One of the most wide spread species is southern naiad. This plant is dark green to purple-brown in color. Leaves are 0.3 to 1.8 inches long and 0.2 to 0.3 inches wide. Marginal teeth on the leaves require magnification to be seen. Leaves are usually opposite or in whorls (Figure 36).

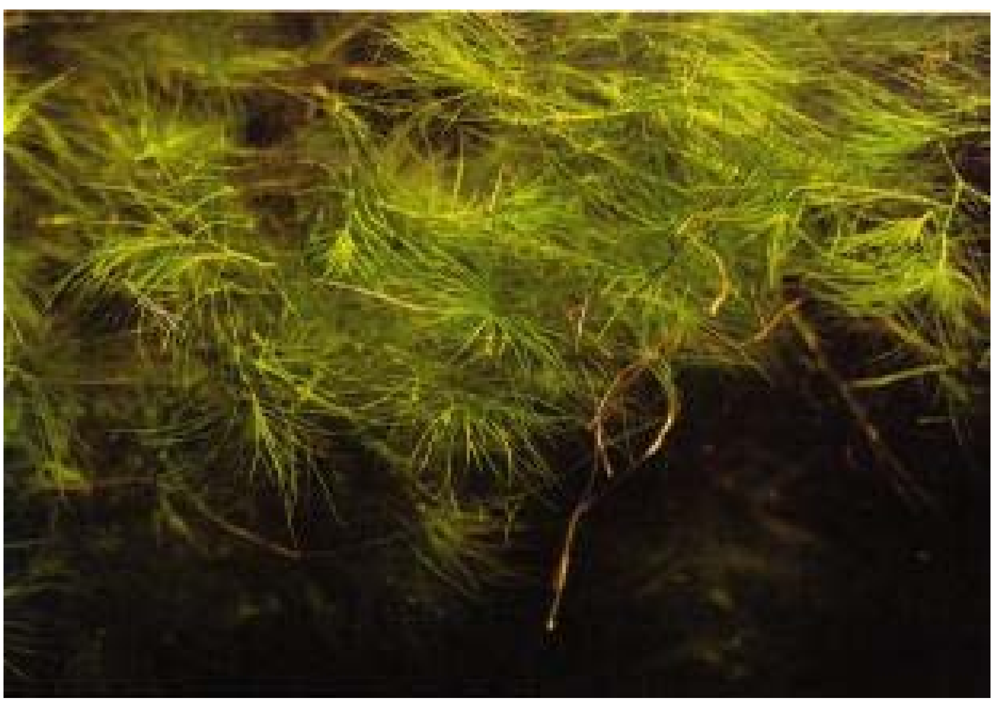


Figure 36. Naiad.

Parrotfeather (*M. brasiliense*)

Parrotfeather is rooted to the bottom but may extend 3 to 12 inches above the water surface (Figure 37). Underwater the stem is quite stout with leaves arranged in whorls with relatively long internodes. Each leaf is 0.8 to 2 inches long and has 10 to 18 narrow comb-like teeth on each side of the mid-rib. Above water, leaves are compacted on shorter internodes and are more delicate in appearance. Above water, leaves are also whorled and vary from yellow to green in color. Parrotfeather is found in most areas of the South.

Figure 37. Parrotfeather.

Mechanical/Physical
Parrotfeather can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume parrotfeather but it is not a preferred food. Grass carp stocking rates to control parrotfeather are usually in the range of 7 to 15 per surface acre.

Chemical
The active ingredients that have been successful in treating parrotfeather include 2,4-D (E), diquat (G), copper with diquat (E), endothall (E), triclopyr (G), fluridone (E), and imazapyr (G). E = excellent, G = good

Navigate and **Aqua-Kleen** is a granular butoxyethyl ester of 2,4-D and has been effective on parrotfeather. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on parrotfeather and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate** are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and come in both liquid and granular formulations. These endothall products have been effective on parrotfeather and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on parrotfeather. Contact herbicides act quickly and kill all plant cells that they contact. Hydrothol can be toxic to fish.

Renovate is a liquid triclopyr formulation that is effective on parrotfeather. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on parrotfeather. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Habitat contains the active ingredient, imazapyr, which inhibits the plant enzyme AHAS (acetohydroxyaced synthase). Habitat is a systemic herbicide that is effective on post-emergent floating and emergent aquatic vegetation. Imazapyr is effective at low-volume rates and does not contain heavy metals, organochlorides or phosphates, making it safe to humans and livestock. Habitat requires the use of a spray adjuvant when applying on post-emergent vegetation.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Russian Knapweed

Watermilfoil (*Myriophyllum* Spp.)

There are several species of *Myriophyllum* common to the Southeast. Generally, this group of plants can be confused with emergent (above water) plants. In some species, the tip may extend 3 to 12 inches above the water. Also, above water leaves may appear to be different from underwater leaves. In all species, underwater leaves are "comb-like" or "feather-like" in appearance and are whorled. Three species are a common management problem in ponds.

Eurasian Watermilfoil (*M. spicatum*)

This species is primarily a problem in the coastal areas of the southeast (Figure 38). This plant is apparently spreading throughout the Southeast. The underwater leaves look like weather-beaten feathers and are whorled. The above water tip has no leaves and may be 2 to 4 inches long.

Figure 38. Eurasian watermilfoil.

Eurasian watermilfoil is a submerged aquatic plant that, when reaching the surface of the water, grows horizontally, creating a mat.

The stem can range from pale pink to red to reddish brown with feathery leaves.

Leaves are divided into leaflets, usually numbering greater than 9 per leaf. The ends of the leaves form a blunt tip, appearing snipped. Between 3 to 5 leaves grow in a whorled pattern around the stem. Many native plants have characteristics that resemble those of invasive aquatic plants. To identify an aquatic plant, begin by observing leaf types and how the leaves are arranged on the plants. Also note any other structures the plant may have such as flowers, fruits, bladders, and root structures.

Accidentally introduced from Europe in the 1940s, Eurasian watermilfoil (Myriophyllum spicatum L.) has become one of the most troublesome submersed aquatic plants in North America. It has spread to at least 45 U.S. states and three Canadian provinces. Although most frequently found in quiet bodies of water (1 - 10 m. deep), it has shown an ability to grow in rapidly flowing water. The plant has been known to degrade shoreline quality, clog propellers, restrict boat access, impair swimming, increase water temperature, and crowd out important native water plants. In some lakes, however, the plant appears to coexist with native flora and has little impact on fish and other aquatic animals. A variety of physical, chemical, and biological control methods have been used in attempts to manage infestations of Eurasian watermilfoil. Unfortunately, complete eradication is rare.

Mechanical/Physical
Eurasian watermilfoil can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish. Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume Eurasian milfoil but it is not preferred and almost the last thing consumed. Grass carp stocking rates to control Eurasian watermilfoil are usually in the range of 7 to 15 per surface acre or more.

Chemical
The active ingredients that have been successful in treating Eurasian watermilfoil include copper complexes (G), 2,4-D (E), diquat (E), endothall (E),triclopyr (E) and fluridone (G). E = excellent, G = good

Navigate and **Aqua-Kleen** is a granular butoxyethyl ester of 2,4-D and has been effective on Eurasian watermilfoil. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on Eurasian watermilfoil and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plants cells that they contact.

Renovate is a liquid triclopyr formulation that is effective on eurasian watermilfoil. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate** are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on Eurasian watermilfoil and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on Eurasian watermilfoil. Contact herbicides act quickly and kill all plants cells that they contact. Hydrothol can be toxic to fish.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on Eurasian watermilfoil. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Daisy Fleabane

Broadleaf Watermilfoil (*M. heterophyllum*)

Broadleaf watermilfoil (not illustrated) is more coarse in appearance than parrot feather. Underwater leaves are also whorled and sparse. Above water, the spike may be 2 to 6 inches long. Leaves are also whorled above water but do not have a feather-like appearance. They may be 0.2 to 1.2 inches long and are serrated along the edges.

Mechanical/Physical

Variable-leaf watermilfoil can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological

Grass carp will seldom control aquatic vegetation the first year they are stocked. They will consume variable-leaf milfoil but it is not preferred. Grass carp stocking rates to control variable-leaf watermilfoil are usually in the range of 7 to 15 per surface acre or more.

Chemical

The active ingredients that have been successful in treating variable-leaf watermilfoil include copper complexes (G), 2,4-D (E), diquat (E), endothall (E), triclopyr (E) and fluridone (G). E = excellent, G = good

Navigate and **Aqua-Kleen**is a granular butoxyethyl ester of 2,4-D and has been effective on variable-leaf watermilfoil. 2,4-D compounds are systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

Reward is a liquid diquat formulation that has been effective on variable-leaf watermilfoil and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate** are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on variable-leaf watermilfoil and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plants cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on variable-leaf watermilfoil.

Contact herbicides act quickly and kill all plant cells that they contact. Hydrothol can be toxic to fish.

Renovate is a liquid triclopyr formulation that is effective on variable leaf watermilfoil. It is a selective broadleaf, systemic herbicide. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides. An aquatically registered surfactant (see the label) will improve the effectiveness of triclopyr.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on variable-leaf watermilfoil. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Elodeas

Included in this group are hydrilla (*Hydrilla verticillata*), egeria or Brazilian elodea (*Egeria densa*) and elodea (*Elodea canadesis*). Hydrilla is a significant problem in Florida and is becoming established in many of the other Southern states (Figure 39). Egeria is more common in Florida but is also established in other areas (Figure 40). Elodea is more common to Northern and Midwestern states and is occasionally found in the Southeast.

Figure 39. Hydrilla.

Figure 40. Egeria.

Hydrilla is a serious threat to fresh water habitats and for this reason it should be distinguished from egeria. The midrib of hydrilla leaves may be red. Leaf margins have strong serrations and large soft spines on the back of the midrib. Usually hydrilla has a harsh scratchy texture while egeria lacks these characteristics.

Hydrilla is very difficult to identify because of the variable characters it has in different habitats. Any aquatic plant identified as egeria, elodea, or hydrilla should be sent to a specialist for positive identification since hydrilla is such a serious threat to fresh water habitats. It is only through early identification and concentrated control methods that there is any hope of eliminating hydrilla. Fishermen or boaters in waters known to have hydrilla should make every effort not to accidentally transport hydrilla from one lake or pond to another.

Scientific Name	*Hydrilla verticillata* (L.f.) Royle
Common Name	Hydrilla
Family	Hydrocharitaceae (Frogbit)
Class	Monocot
Description	Perenniating mostly from tubers, propagates from tubers, turions, root crowns, and fragments; partially evergreen; white flowers
US Distribution	Diocieous form: southeastern US, Texas, California. Monoecious form: Maryland, North Carolina, Virginia, Delaware, California.
Worldwide Distribution	Scattered subtropical regions: Australia, China, US, New Zealand; native of China
Ecology	Submersed in 1 up to 20 feet depth
Economic Importance	Major nuisance impact on US systems ($8M/yr in Florida)

Ecological Importance	Major impact on aquatic ecosystems
Notes	Has both monoecious and diocieous forms; no sexual propogation in diocieous form

Mechanical/Physical
Elodea can be removed by raking or seining it from the pond but will reestablish from any remaining fragments and roots.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization. **Aquashade** is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will readily consume elodea. Grass carp stocking rates to control elodea are usually in the range of 7 to 15 per surface acre.

Chemical
Active ingredients that have been successful in treating elodea include diquat (E) and fluridone (E). E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on elodea. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Sonar and **Avast** are fluridone compounds and come in both liquid and granular formulations and have been effective on elodea. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Fanwort (*Cabomba* Spp.)

The submersed leaves of fanwort are "fan-like" in shape and made up of many thread-like elements (Figure 41). The stem may be covered with a gelatinous material. The floating leaves are few and of different shapes. Floating leaves may be long and narrow or oval in shape.

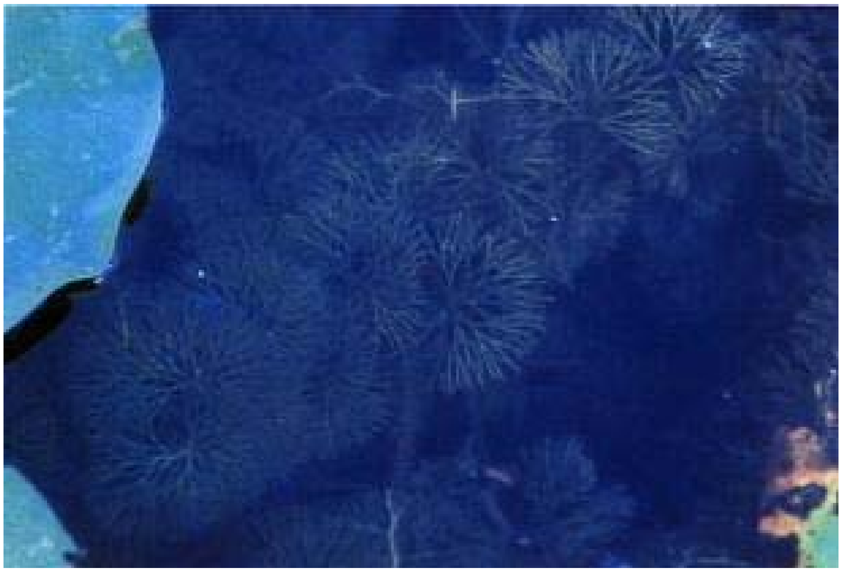


Figure 41. Fanwort.

Sago Pondweed

Sago Pondweed

Scientific Name	*Potamogeton pectinatus* L.
Common Name	Sago Pondweed
Family	Potamogetonaceae (Pondweed)
Class	Monocot
Description	Submersed rooted, alternate long narrow leaves with distinct point, flowers emergent and inconspicuous, wind or water pollinated, reproduces by stolons and both subterranean and auxiliary tubers
US Distribution	Throughout North America
Worldwide Distribution	Almost worldwide
Ecology	Submersed in both static and flowing waters
Economic Importance	May form nuisance growths in eutrophic streams and ditches
Ecological Importance	Highly important habitat and food for waterfowl and aquatic organisms, waterfowl eat tubers, foliage, and seeds
Notes	Then genus and family are the most important taxa to submersed aquatic communities in North America, and possibly worldwide

Mechanical/Physical
Sago pondweed can be removed by raking or seining it from the pond but will reestablish from any remaining roots and seeds.

Fertilization to produce a phytoplankton or algal "bloom" prevents the establishment of most bottom rooted aquatic weeds and produces a strong food chain to the pond fish.

Non-toxic dyes or colorants prevent or reduce aquatic plant growth by limiting sunlight penetration, similar to fertilization.

Aquashade is an example of non-toxic dye and other products are available. However, dyes do not enhance the natural food chain and may suppress the natural food chain of the pond.

Biological
Grass carp will seldom control aquatic vegetation the first year they are stocked. They will readily consume sago pondweed. Grass carp stocking rates to control sago pondweed are usually in the range of 7 to 15 per surface acre.

Chemical
The active ingredients that have been successful in treating sago pondweed include diquat (G), copper with diquat (G), endothall (E), and fluridone (E). E = excellent, G = good

Reward is a liquid diquat formulation that has been effective on sago pondweed and is very effective if mixed with a copper compound. It is a contact herbicide. Contact herbicides act quickly and kill all plant cells that they contact.

Cutrine Plus, **K-Tea**, **Captain**, and **Clearigate**are all chelated or compound copper herbicides and can be used in a mixture with Reward or Aquathol K. Other chelated or compound copper formulations are available but are not linked to this web site.

Aquathol, **Aquathol K**, and **Aquathol Super K** are dipotassium salts of endothall and comes in both liquid and granular formulations. These endothall products have been effective on sago pondweed and can be mixed with copper compounds for additional effectiveness. Contact herbicides act quickly and kill all plant cells that they contact.

Hydrothol 191 is an alkylamine salt of endothall and comes in both liquid and granular formulations. It is a contact herbicide and has been effective on sago pondweed. Contact herbicides act quickly and kill all plants cells that they contact. Hydrothol can be toxic to fish.

Sonar and **Avast** are fluridone compounds, come in both liquid and granular formulations, and have been effective on sago pondweed. These are broad spectrum, systemic herbicides. Systemic herbicides are absorbed and move within the plant to the site of action. Systemic herbicides tend to act more slowly than contact herbicides.

One danger with any chemical control method is the chance of an oxygen depletion after the treatment caused by the decomposition of the dead plant material. Oxygen depletions can kill fish in the pond. If the pond is heavily infested with weeds it may be possible (depending on the herbicide chosen) to treat the pond in sections and let each section decompose for about two weeks before treating another section. Aeration, particularly at night, for several days after treatment may help control the oxygen depletion.

Pondweeds (*Potamogeton* Spp.)

Pondweeds are the largest group of aquatic plants (Figures 42, 43). Different species are quite varied in their appearance. Some members of this group are very difficult to control. In many species, the leaves are usually alternate and the underwater leaves are often ribbon-like and less firm in texture than the floating leaves. The flowers and fruits are on spikes extending above the water surface. Leaves may vary from thread-like to large oval- or lance-shaped.

Figure 42. Pondweed.

Figure 43. Pondweed.

Aquatic Life Evaluation Section

Evaluating a pond is a simple, critical, and often overlooked step in the successful control of aquatic weeds. An evaluation of the pond will help the owner select and apply the most efficient, effective, and economical control measure. A pond evaluation should include the following: an inventory of pond water and watershed uses; an appraisal of the physical conditions of the pond and watershed; knowledge of some of the water chemistry; and the pond water volume.

Pond and Watershed Uses
Most pond owners already know the various uses of their pond and watershed. However, pond and watershed uses need to be considered when attempting to control aquatic weeds. This is especially true if herbicides are used. For example, aquatic herbicides applied to a pond used for irrigation may have a disastrous effect upon the irrigated crops. In most instances, a conflicting water use (such as irrigation) can be temporarily stopped until the herbicide has dissipated from the water. In other situations, this may not be practical and an alternative control measure should be used. If herbicides are used, water uses should be compared to restrictions listed on the label. Some water uses which may interfere with aquatic weed control are: irrigation, boating, swimming, watering livestock, sportfishing and commercial fish production.

Physical Conditions
Various physical conditions may contribute to an aquatic weed problem or interfere with attempts to control it. Ponds which have extensive areas of shallow water or receive organic runoff usually have aquatic weed problems. Attempts to control weeds in these ponds are usually unsuccessful unless the pond is deepened or the source of organic runoff is removed or diverted around the pond. Deepening a pond or eliminating organic runoff can be considered control methods and are discussed in the "*Methods of Aquatic Weed Control"* section. Excessive amounts of water flowing through a pond can interfere with aquatic weed control. Ponds which are constructed on constantly flowing streams, or have an excessively large watershed, or have a large number of springs can be difficult to manage for aquatic weeds. Excessive water flow may interfere with the following weed control measures: fertilization, herbicides, and fall-winter drawdowns.

Pond Water Chemistry
When controlling aquatic weeds with herbicides or fertilizer, it is important to know something about the chemistry of the water in the pond. Water hardness can affect herbicide and fertilizer applications. The water hardness also should be considered when using herbicides containing copper. Water hardness--Generally, water hardness is a measure of the calcium and magnesium in the water. In hard waters (above 50 parts per million hardness) it may be necessary to apply greater amounts of herbicide in order to achieve control. In soft waters (below 50 parts per million hardness) some herbicides are more toxic to fish and plants. Herbicides which may be affected by water hardness have precautions listed on their labels. Water hardness is also an indicator of the lime requirement for the pond. See the section on Pond Fertilization. Many areas of the south have soft water. Pond owners should be familiar with the water hardness of their pond. Pond water hardness can be measured by most state Extension services or state game and fish departments. Copper--In soft water some heavy metals, especially copper, can be toxic to fish. Some herbicides contain copper and should be used with caution in soft water ponds (less than 50 parts per million water hardness).

Pond Water Volume

Pond owners should know the water volume of their ponds. Most chemical application rates are based upon water volume. This is true for chemicals used to treat aquatic weeds, fish diseases, and oxygen depletions. The volume of water in a pond is usually expressed in acre-feet. An acre-foot of water is one surface acre that is one foot deep. A pond having three surface acres and an average depth of 6 feet has a total water volume of 18 acre-feet. Table 1 can be used to convert acre-feet to other expressions of volume and weight.

Most county Soil Conservation Service offices can assist pond owners in determining the water volume of their ponds. Assuming the surface area of the pond is known, the following method can be used to determine the average depth of a pond. Average depth can be determined by use of a sounding line at regular intervals along several transects of the pond. Both deep and shallow areas of the pond should be included in the transects. Average depth is computed by adding all of the depth measurements and dividing by the number of measurements. The average depth multiplied by the surface area should give an accurate estimate of the pond water volume.

Table 1. Equivalents of I acre-foot and amount of chemical added per unit volume to give one part per million (ppm) (Conversion Factor).

1 acre foot = 43,560 cubic feet	1 ppm = 2.72 pounds per acre foot
1 acre foot = 325,830 gallons of water	
1 acre foot = 2,718,144 pounds of water	

Methods of Aquatic Weed Control

Methods of aquatic weed control include preventive measures, as well as mechanical, biological, and herbicidal controls. Each method has advantages and disadvantages. The best approach is to consider preventive measures first. If they are not practical or do not produce the desired results, then other control methods should be considered. It is always easier and more economical to prevent a weed problem than to cure one. Even when preventive measures are only partially successful, they quite often facilitate the effectiveness of other control measures.

Preventative Measures

Preventive measures include proper pond location and construction, fertilization and fall-winter drawdowns. If one or all of these practices are followed, the need for herbicide use in many southern ponds will be reduced.

Pond Location

Careful selection of a pond site can help prevent weed problems. A flowing stream is not a good location for the construction of a pond. Excessive water flow will prevent successful fertilization and complicate herbicide applications. This is also true of ponds with excessive watershed-to-pond surface area ratios. The recommended watershed-to-pond ratio depends on land use, vegetative cover, soil type, and slope of the land. Generally, a watershed of 10 to 20 acres per surface acre of pond is recommended for woodland, while 5 to 10 acres is recommended for pastureland.

Construction of ponds in watersheds that have highly fertilized fields, barnlots, septic tank fields, or other sources of organic runoff should be avoided.

Enrichment of a pond with organic material will promote weed growth. Existing ponds with excessively large watersheds or sources of organic pollution in the watershed may benefit from the construction of a diversion ditch to direct some of the runoff around the pond.

Pond Construction

Most algae and submersed or emersed rooted aquatic weeds usually start growing in shallow water 2 feet deep or less. Once established, they will often extend into deeper water areas. Ponds should be constructed so there is little, if any, water less than two feet deep. In existing ponds, it may be practical to deepen shallow water areas.

Fertilization

In properly constructed ponds, establishment and growth of aquatic weeds is best prevented by fertilization. Fertilization stimulates the growth of desirable algae so sunlight cannot penetrate to the bottom and rooted aquatic weeds cannot become established (Figures 44, 45). In ponds with established aquatic weeds, these plants generally die down during the winter. If fertilization is begun before weeds begin spring growth, in most instances they will not become re-established. If fertilization is begun after weeds have become established, fertilizer will be taken up by the weeds. This will produce heavier weed growth. Fertilization should begin as early as possible in spring before weed growth starts.

Herbicidal Treatment

Herbicidal treatment of a weed problem in the spring followed by a fertilization program is often a good weed control measure. In some areas of the southeast, pond fertilization may not be recommended or recommendations described below may be modified because of area differences in watershed uses and fertility. For local fertilizer recommendations, consult with your county Extension agent or state game and fish personnel.

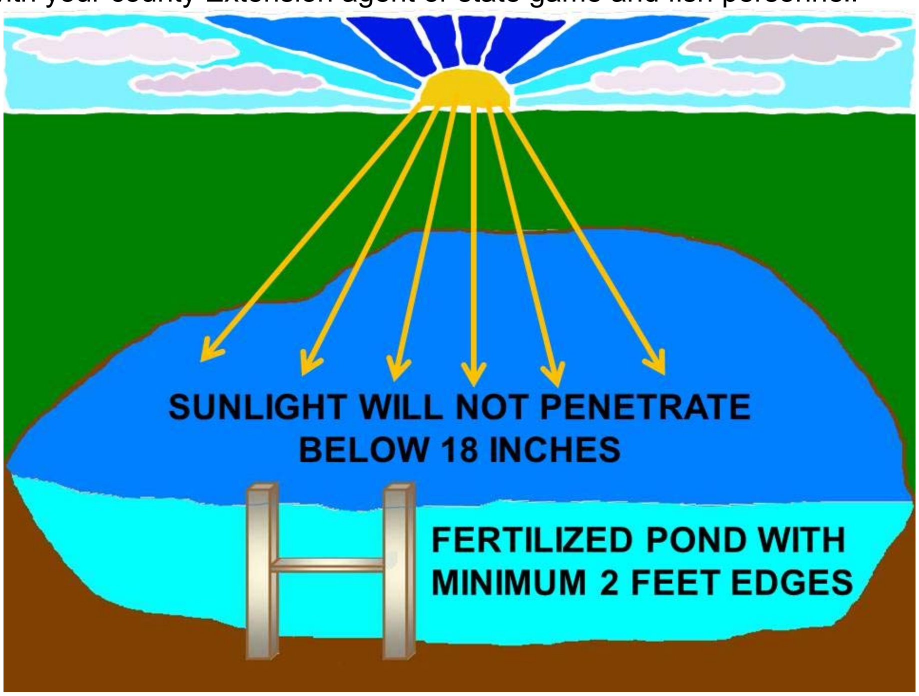


Figure 44.

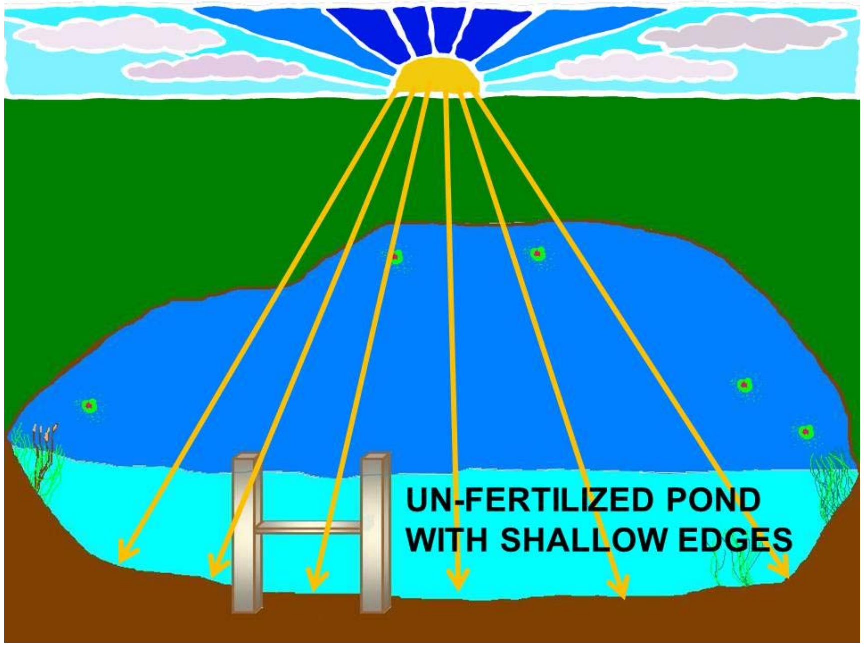


Figure 45.

Begin fertilizing with 40 pounds of 20-20-5 per surface acre in late February or early March when water temperature stabilizes above 60°F. If after two weeks you can see a bright object more than 18 inches beneath the surface, proper water color resulting from plankton algae growth has not been developed. Fertilize again at the same rate.

If proper color does not develop following the third application, test the pond for lime requirements. Proper color can be maintained by fertilizing with 40 pounds of 20-20-5 per surface acre when a bright object can be seen more than 18 inches into the water. Fertilization will probably be necessary about once a month. Stop fertilization when water temperature stabilizes below 65°F. This is usually in October or November.

Method of Application

The most economical method of application is to pour the fertilizer on a platform constructed 12 to 18 inches below the water surface (Figure 46). There should be at least three square feet of platform for each surface acre in the pond. Fertilizer placed on platforms will dissolve slowly in the upper layer of water (where desirable algae production occurs) and will be distributed by wind. Locate the platform 10 to 15 feet from the shore so the fertilizer will receive maximum wind distribution.

Other acceptable methods of application include: broadcasting fertilizer by hand in shallow water less than four feet deep, or pouring it in a line 15 feet from shore in shallow areas, or slitting fertilizer bags and placing them in shallow water.

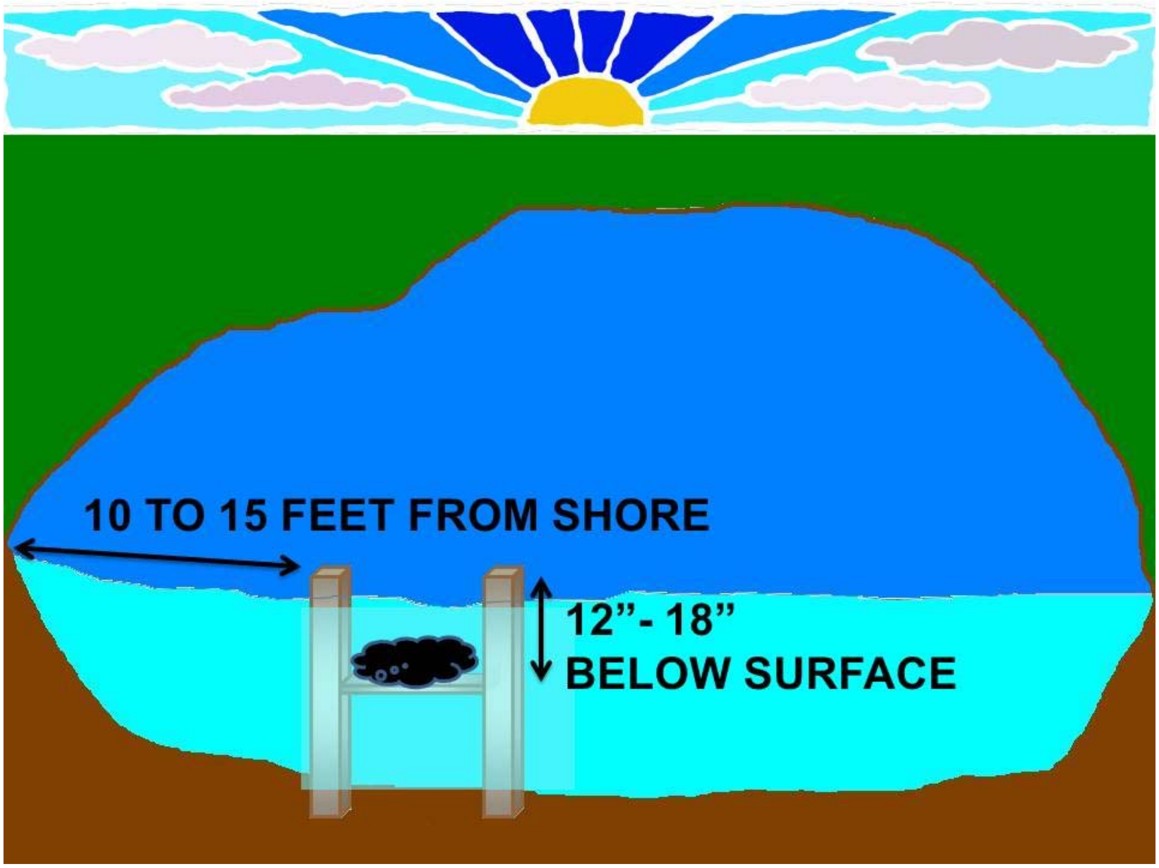


Figure 46. Fertilizer platform.

Liming

Lime is as necessary for plant production in ponds as it is on fields. Softwater ponds should be limed before fertilization, this can be effective in producing a bloom of desirable algae. Many Southern ponds should be limed every two to four years.

Liming requirements can be determined by your county Extension agent or state game and fish personnel. Agricultural lime is used for liming ponds. Although agricultural lime may be added at any time, it takes about three months for it to go into solution. Lime should be distributed throughout the pond during fall so it will be in solution the following spring when fertilization begins.

Fall-Winter Drawdown

Decreasing the water level of a pond is called a drawdown. Drawdowns are beneficial in controlling weeds and correcting mildly crowded bream populations. If a drawdown is used for two or four consecutive years, as much as 90 percent of the submerged vegetation in a pond can be eliminated. Drawdowns expose the shallow areas of a pond to winter weather and drying, thus eliminating some of the weeds (Figure 47). A pond should be drawn down in November and this lowered water level maintained until spring (February or March). Drawdowns should never be used in warm weather months or in ponds smaller than one surface acre. The pond water surface area should be reduced at least one-third and not more than one-half.

Figure 47. Fall-winter drawdown.

Mechanical Methods
Some rather sophisticated machines have been developed to control aquatic weeds. These machines either cut or drag weeds from a pond. Unfortunately their operation is expensive and not practical for most privately owned ponds. Seining or raking weeds out of the water can be an effective control method in small ponds. Because of the labor involved, it is not practical in larger bodies of water.

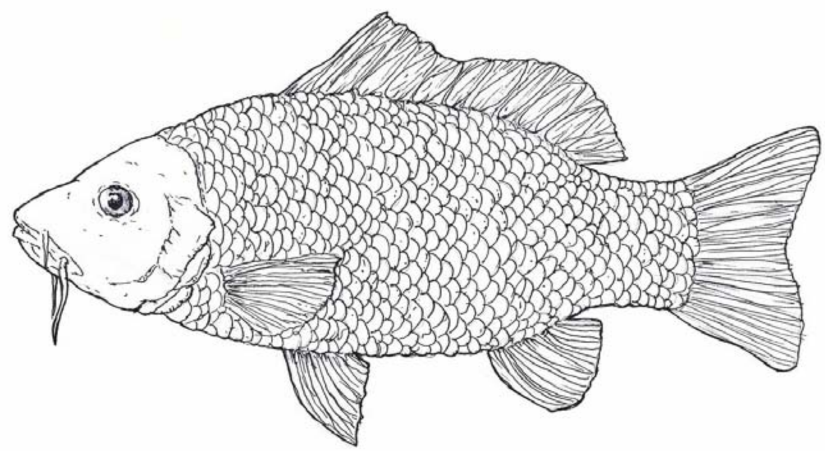
Seining or raking weeds can be used to temporarily clear small shallow bays or beach areas in large ponds. Sun screening or shading materials have been used to successfully control weeds in some ponds.

These materials either restrict or shade-out plant growth. Generally, their use is not practical in large ponds. Black plastic sheeting, for example, can be spread out and weighted down on the bottom in a swimming beach area to control submersed weeds. This plastic should be left in place for about two weeks in order to achieve temporary control.

Biological Methods

Biological controls of aquatic weeds are a new and promising development in pond management. A biological control is some living agent, whether it is fish, insect, or bacteria, which is harmful to and attacks the nuisance aquatic plant. Most biological agents are organisms which are not native to this country and thus must be studied to determine whether they may have any negative effects upon the environment prior to release. In some states, the grass carp or white amur (Ctenopharyngodon idella) is being used to aid in control of aquatic weeds (Figure 48).

The grass carp is not a native fish to this country. The use of grass carp for aquatic weed control is presently highly controversial. It is the general opinion of many biologists that the grass carp is a potential hazard to our native fish and waters and not enough information is available to recommend its use. In most states it is illegal to stock this fish. Do not stock grass carp in ponds in states where their use is prohibited. And, never stock the fish without first consulting with state game and fish department personnel or a qualified fisheries biologist.



CARP ***(Carpio cyprinus)***

Figure 48. Grass carp.

Chemical Methods
Aquatic herbicides are safe and effective if they are selected and applied properly. Choosing the right herbicide does not guarantee success. It must also be applied properly and all warnings and precautions concerning use should be understood and observed. Fortunately, all of this information is on the herbicide label. Anyone who uses an aquatic herbicide should always thoroughly read and understand the herbicide label before purchasing and applying the chemical.

County extension agents and state fisheries biologists can advise pond owners who have questions concerning aquatic herbicide selection, methods and rates of application, precautions, and state and federal regulations. The information in this section is not intended to replace the information on the herbicide label. Rather, it should be used to supplement label information.

Selection of an Aquatic Herbicide
Identification of the weed, knowledge of pond water volume or surface area, and water uses will help the pond owner select the most effective and economic aquatic herbicide.

Weed Identification
No single aquatic herbicide is capable of controlling all kinds of weeds that are potential problems in the management of a pond. For this reason, it is important to identify the weed before attempting to control it with a herbicide. Herbicide labels list the aquatic weeds which will respond to treatment with that particular herbicide. Table 2 lists the aquatic weeds described in this publication and the herbicides which are usually effective in their control.

Pond Water Volume and Surface Area
Herbicide application rates are determined either by the pond's water volume or by surface area. Most herbicide labels list application rates according to one or the other of these measures. Some herbicide application rates will vary depending upon the weed species and the extent of infestation. Prior knowledge of the pond's water volume and surface area will aid in the selection of the most economical herbicide and insure the proper amount is purchased and applied.

Pond Water Uses
Restrictions and cautions of herbicide use will vary depending upon the herbicide. This information is on the herbicide label. If pond water uses are not compatible with the restrictions and cautions listed for a specific herbicide, an alternate herbicide should be selected, or another aquatic weed control measure used.

Herbicide Application
It is not enough to select the right herbicide. The herbicide must also be applied properly. The herbicide applicator must be knowledgeable of the herbicide formulation, methods and rates of application, precautions and warnings, and other information specific to the herbicide.

Formulation
Herbicide formulations vary in the amount of active ingredients present. The active ingredients are the chemicals which actually kill the pest or weed. Inert ingredients are added to improve the convenience, safety, and handling of the herbicide. Herbicide application rates are based upon the active ingredient in the herbicide formulation. This is one reason why it is always important to determine herbicide application rates from information printed on the label.

Methods of Application
Some herbicides can be applied directly from the container (ready for use) and others need to be diluted with water or some other dilutent before application. Always follow label directions. Dispersion of the herbicide is also important. In small ponds, for shoreline areas or "spot treatments," many of the herbicides can be applied by simply broadcasting the chemical over the area. Most of the granular formulations can be scattered directly. In small areas, some liquid formulations can be poured over the area but others need to be diluted and may be applied with a sprinkling can. Treatment of large areas usually require the use of mechanical sprayers or spreaders and a boat with an outboard motor to ensure that the chemical is adequately dispersed.

Most aquatic herbicides can be applied with a hand operated seeder, pressurized sprayer, or boat bailer. Injecting the chemical near the outboard motor prop wash will help in dispersion. Some herbicides are "contact killers," that is, they must come into direct contact with the plant. For this reason, contact herbicides must be evenly dispersed in or on the water to have maximum effectiveness. Other herbicides must be absorbed by the plant to be effective and are called "translocated" herbicides.

Floating Weeds

Control of floating weeds usually requires a surface spray application as the least expensive method, as compared with treatment of the total volume of water.

Emersed (above water) Weeds

Control of emersed weeds may permit a choice of methods, depending upon the specific weed. If a large portion of the leaf area is above water, surface spray applications may be the most effective and least expensive method. Application of aquatic granules or pellets may also be substituted, but this is usually more expensive. Treatment of other weeds may permit gravity flow application, where the undiluted herbicide is poured slowly into the pond from a boat propelled across the surface in a regular pattern. Wind and water currents disperse and dilute the herbicide to the desired concentration.

Submersed (underwater) Weeds

Control of submersed weeds is not usually practical with surface spray applications. Gravity flow application is sometimes utilized but may be wasteful of herbicide. Herbicides are more effective in an aquatic situation if placed close to the root system or leaf area of the plant. Granule or pellet formulations are more frequently used to accomplish this. Another variation is the use of specialized equipment, used by commercial applicators, which places liquid herbicides in the "bottom acre-foot" of water near the site of uptake by the plant. The greater specific gravity of the herbicide holds the treatment in higher concentration near the plant for improved control.

Rates and Time of Application

If it is necessary to use aquatic herbicides in the management of a pond, it is best to apply them in the spring or early summer. Most aquatic herbicides can be effectively applied when water temperatures are above 55°F or when aquatic weeds show signs of new growth. Advantages of spring or early summer treatment are: 1. There is less of a chance of oxygen depletion and fish kills. 2. For some herbicides, a smaller amount of chemical is needed for control. 3. Many herbicides are more effective on plants in the early growth stages. Also, total plant mass is less, so less herbicide is required. 4. Early application of herbicides often facilitates later non-herbicide control measures such as fertilization.

Application rates should always be based upon label recommendations. However, if a pond has a heavy infestation of weeds it is wise to treat a fraction of the weeds in the pond at a time, waiting two or three weeks between applications. During the warm summer months, never treat the entire pond with a herbicide at one time, no matter how minor the weed infestation. Dead and decaying plants consume oxygen from the water. Treating a fraction (Figure 49) of the pond will allow the fish to escape to oxygenated water during the decay process and reduce the chances of a fish kill. When using herbicides, never wait until a pond has become choked by aquatic weeds. Instead, spot treat areas of weed growth early, before they become a problem.

Figure 49. Partial herbicide treatment.

Precautions and Warnings
Specific information concerning precautions and warnings is printed on the herbicide label. These precautions and warnings are listed to help ensure that no health hazard occurs because of their use. The following are applicable to any aquatic herbicide:

ATTENTION: Herbicide Precautions

1. Observe all directions, restrictions and precautions on herbicide labels. It is dangerous, wasteful and illegal to do otherwise.
2. Store all herbicides in original containers with labels intact and behind locked doors.
3. Use herbicides at correct dosage and intervals to avoid illegal residues or injury to animals.
4. Apply herbicides carefully to avoid drift.
5. Dispose of leftover herbicides and containers according to the directions on the label.

Aquatic Herbicide Section

Aquatic herbicides are chemicals specifically formulated for use in water to kill or control aquatic plants. Herbicides approved for aquatic use by the United States Environmental Protection Agency (**EPA**) have been reviewed and are considered compatible with the aquatic environment when used according to label directions. However, some individual states impose additional constraints on their use.

Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants or are applied to the water in either a liquid or pellet form. **Systemic herbicides** are capable of killing the entire plant. **Contact herbicides** cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and able to regrow. **Non-selective**, broad spectrum herbicides will generally affect all plants that they come in contact with. **Selective** herbicides will affect only some plants (often dicots - broad leafed plants like Eurasian watermilfoil (*Myriophyllum spicatum*) will be affected by selective herbicides, whereas monocots like Brazilian elodea (*Egeria densa*) may not be affected. Most aquatic plants are monocots.

Endothall

What is Endothall and how is it used?
Endothall is an organic solid of white odorless crystals. Endothall is used as a defoliant for a wide range of crops and as a herbicide for both terrestrial and aquatic weeds. It is used as a desiccant on lucerne and on potato, for the defoliation of cotton, to control aquatic weeds and as an aquatic algaecide growth regulator. It has been used for: sugar beets, turf, hops sucker suppression; alfalfa, clover desiccants; potato vine killers.

The list of trade names given below may help you find out whether you are using this chemical at home or work.

Trade Names and Synonyms:
Accelerate
Aquathol
Des-i-cate
Endothall Turf Herbicide
Endothall Weed Killer
Herbicide 273
Hydrothol
Herbon Pennout
Hydout

Why is Endothall being Regulated?
In 1974, Congress passed the Safe Drinking Water Act. This law requires the EPA to determine safe levels of chemicals in drinking water which do or may cause health problems. These non-enforceable levels, based solely on possible health risks and exposure, are called Maximum Contaminant Level Goals.

What are the Health Effects?
Short-term: The EPA has found endothall to potentially cause the following health effects when people are exposed to it at levels above the MCL for relatively short periods of time: depressed breathing and heart rate. Long-term: Endothall has the potential to cause the

following effects from a lifetime exposure at levels above the MCL: increase in size of some internal organs, particularly the stomach and intestine.

How much Endothall is produced and released to the environment?
The EPA estimated total domestic usage in 1982 to have been approximately 1.5 million lbs. Release of endothall to the environment is expected to occur primarily during its use as a pre-emergence, post-emergence, turf and aquatic herbicide and harvest aid. Other sources of release include loss during manufacturing, formulation, packaging or disposal of this herbicide.

What happens to Endothall when it is released to the environment?
Endothall is expected to be quickly broken down by microbes in soil or water. It is also able to leach through soil into ground water; however, rapid degradation would limit the extent of leaching. Endothall is not likely to accumulate in aquatic life.

TRADE OR OTHER NAMES: Endothall is endothal in Great Britain. Trade names for the acid form of endothall (technical endothall) include Aquathol, Hydrothal-47 and Hydrothal-191. Trade names for the disodium salt of endothall (disodium endothall) include Accelerate, Des-I-Cate, Tri-endothal, Ripenthol, Hydrothol, and Niagrathol. The amine salt of endothall is also called Hydrothol.
REGULATORY STATUS: Endothall is a general use pesticide (GUP). When used as an aquatic herbicide, some water use restrictions may apply.
INTRODUCTION: Endothall is a member of the dicarboxylic acid chemical class. It is a selective contact herbicide. The potassium and amine salts of endothall are used as aquatic herbicides to control a variety of plants including plankton, pondweed, naiad, coontail, milfoil, elodea, and algaes in water bodies and rice fields. Endothall is also used to control annual grasses and broadleaf weeds in sugar beets, spinach and turf. It reduces sucker branch growth in hops. Endothall is a desiccant to aid the harvest of alfalfa, potatoes, clover, and cotton. The EPA has classified endothall as Toxicity Class II - moderately toxic. Products containing endothall bear the SIGNAL WORD: **WARNING**.
FORMULATION: It is available as granules or as a soluble concentrate.
TOXICOLOGICAL EFFECTS

- **Acute Toxicity:** Endothall is moderately toxic. The LD50 is the dose which kills half of the test animals treated. The oral LD50 for disodium endothall is 51 mg/kg for rats and 250 mg/kg for guinea pigs. The LD50 is 750 mg/kg for rats and 100 mg/kg for rabbits whose skin is exposed to disodium endothall. In humans, ingestion of 7 to 8g of disodium endothall causes repeated vomiting, hemorrhages, swelling in the lungs, and bleeding in the gastrointestinal tract. The LD50 for the amine salt of endothall is 206 mg/kg for rats and 143 mg/kg for rabbits whose skin is exposed to it. The oral LD50 for technical endothall is 38 mg/kg for rats. Endothall is very irritating to the eyes, skin, and mucous membranes.
- **Chronic Toxicity:** Information follows.
- **Reproductive Effects:** A three generation study was conducted by feeding male and female rats disodium endothall until they were 100 days old and then mating them. Three successive generations were maintained on the test diet for 100 days and then bred to produce the next generation. When examined at 21 days, rat pups in all three generations whose parents were given 15 mg/kg/day of disodium endothall had decreased body weights. No adverse reproductive effects were observed (NOEL) at 5 mg/kg/day.There were no observable signs of developmental toxicity at dose levels that were fatal to the females.

- **Teratogenic Effects:** Technical endothall was not teratogenic at the highest dose tested, 30 mg/kg/day.
- **Mutagenic Effects:** Studies show that technical endothall is not mutagenic in Salmonella bacteria nor in mouse cells. Aquathol K, a formulation of dipotassium endothall, is not mutagenic in fruit flies, mold, or human white blood cells. However, "commercial endothall," with no further description, was mutagenic in fruit flies.
- **Carcinogenic Effects:** No statistically significant numbers or types of tumors were observed in rats fed as much as 125 mg/kg/day of disodium endothall for two years. Thus, available evidence suggests that endothall does not cause cancer.
- **Organ Toxicity:** In male dogs, high doses of 20 mg/kg/day of disodium endothall for 6 weeks caused vomiting, diarrhea, damaged intestinal walls, and hemorrhages in the stomach. In rats, very high doses of 50 mg/kg/day of disodium endothall for four weeks caused liver and kidney damage.
- **Fate in Humans and Animals:** In rats dosed with technical endothall, over 95% of the dose was excreted within 48 hours. Within 72 hours after dosing, 99% of the dose was excreted. Approximately 90% of a dose of technical endothall is excreted in the feces and 7% in urine.

ECOLOGICAL EFFECTS

- **Effects on Birds:** No information is currently available.
- **Effects on Aquatic Organisms:** Endothall is toxic to some species of fish. Inorganic salts of endothall in aquatic formulations are safe to fish in 100-500 ppm concentrations. However, amine salts of endothall are more toxic to fish than the dipotassium endothall. Endothall has a low toxicity to crustaceans and a medium toxicity to aquatic insects. Long-term ingestion may cause severe damage to the digestive tract, liver and testes in fish.
- **Effects on Other Animals (Nontarget species):** Endothall is not toxic to bees.

ENVIRONMENTAL FATE

- **Breakdown of Chemical in Soil and Groundwater:** Endothall is highly mobile in soil, however rapid degradation limits the extent of leaching. Endothall disappears from soil in 7-21 days. The half-life (the amount of time needed for the concentration to be reduced by half) of endothall in soil is 4-5 days in clay soils and 9 days in soils with high organic content.
- **Breakdown of Chemical in Surface Water:** Endothall is rapidly degraded in water. Its half-life is 4 to 7 days for dipotassium endothall and about 7 days for technical endothall in surface water. It biodegrades more slowly when air is not present.
- **Breakdown of Chemical in Vegetation:** No information is currently available.

PHYSICAL PROPERTIES AND GUIDELINES

Physical Properties: All properties are for technical endothall unless otherwise noted.

- **Appearance:** Technical endothall is a colorless or white crystal which is stable to light, weak acidic media and weak alkaline media.
- **Chemical Name:** 3,6-endoxohexahydrophthalic acid (technical endothall),Disodium-3,6-endoxohexahydrophthalate (disodium endothall), 3,6-endoxohexahydrophthalic acid amine salt (amine salt of endothall)
- **CAS Number:** 145-73-3 (technical endothall), 129-67-9 (disodium salt of endothall), 6385-60-0 (amine salt of endothall)
- **Molecular Weight:** 186.2
- **Water Solubility:** 100 g/kg at 20 degrees C

- **Solubility in Other Solvents:** Soluble in benzene, isopropanol, acetone, dioxane, and methanol (disodium salt of endothall and technical endothall)
- **Melting Point:** 144 degrees C
- **Vapor Pressure:** 2.09 x 10-5 mPa (24.3 degrees C)
- **Partition Coefficient:** Not Available
- **Adsorption Coefficient:** -0.87

Exposure Guidelines: All guidelines are for technical endothall unless otherwise noted.

- **ADI:** 0.02 mg/kg
- **MCL**:0.1 mg/l
- **RfD:** 0.02 mg/kg/day
- **PEL:** Not Available
- **HA**: 0.8 mg/l
- **TLV**: Not Available

BASIC MANUFACTURER:
ELF Atochem, North America
Three Parkway, Room 619
Philadelphia, PA 19102 Telephone: 215-587-7885

Young Eagle at a wetland project.

Diquat dibromide

Trade and Other Names: Trade names include Aquacide, Aquakill, Dextrone, Diquat, Reglone, Reglox, Reward, Tag, Torpedo, Vegetrole, and Weedtrine-D.

Regulatory Status: Diquat dibromide is a moderately toxic compound in EPA toxicity class II [1,2]. It is a General Use Pesticide (GUP). Labels for products containing diquat dibromide must bear the Signal Word **WARNING**.

Chemical Class: desiccant

Introduction: Diquat dibromide is a nonselective, quick-acting herbicide and plant growth regulator, causing injury only to the parts of the plant to which it is applied. Diquat dibromide is referred to as a desiccant because it causes a leaf or an entire plant to dry out quickly. It is used to desiccate potato vines and seed crops, to control flowering of sugarcane, and for industrial and aquatic weed control. It is not residual; that is, it does not leave any trace of herbicide on or in plants, soil, or water.

Formulation: Not Available

Toxicological Effects:

- **Acute toxicity:** Diquat dibromide is moderately toxic via ingestion, with reported oral LD50 values of 120 mg/kg in rats, 233 mg/kg in mice, 188 mg/kg in rabbits, and 187 mg/kg in guinea pigs and dogs. Cows appear to be particularly sensitive to this herbicide, with an oral LD50 of 30 to 56 mg/kg. The acute dermal LD50 for diquat dibromide is approximately 400 to 500 mg/kg in rabbits, indicating moderate toxicity by this route as well. A single dose of diquat dibromide was not irritating to the skin of rabbits, but repeated dermal dosing did cause mild redness, thickening, and scabbing. Moderate to severe eye membrane irritation occurred when diquat dibromide was administered to rabbits. Ingestion of sufficient doses may cause severe irritation of the mouth, throat, esophagus, and stomach, followed by nausea, vomiting, diarrhea, severe dehydration, and alterations in body fluid balances, gastrointestinal discomfort, chest pain, diarrhea, kidney failure, and toxic liver damage. Skin absorption of high doses may cause symptoms similar to those that occur following ingestion. Very large doses of the herbicide can result in convulsions and tremors. Test animals (rats, mice, guinea pigs, rabbits, dogs, cows, and hens) given lethal doses of diquat dibromide showed a delayed pattern of illness, with onset approximately 24 hours following dosing, subsequent lethargy, pupil dilation, respiratory distress, weight loss, weakness and finally death over the course of 2 to 14 days after dosing. There have been reports of workers who have had softening and color changes in one or more fingernails after contact with concentrated diquat dibromide solutions. In some instances, the nail was shed, and did not grow in again. Several cases of severe eye injury in humans have occurred after accidental splashings. In each case, initial irritation was mild, but after several days, serious burns and sometimes scarring of the cornea developed. Direct or excessive inhalation of diquat dibromide spray mist or dust may result in oral or nasal irritation, nosebleeds, headache, sore throat, coughing, and symptoms similar to those from ingestion of diquat.
- **Chronic toxicity:** Chronic effects of diquat dibromide are similar to those of paraquat. Cataracts, a clouding of the eyes which interferes with light entering the

eye, occurred in rats and dogs given 2.5 mg/kg/day and 5 mg/kg/day of diquat dibromide, respectively. Cataracts increased in proportion to the dose given in test animals (cats and dogs). Chronic exposure is necessary to produce these effects. Other effects on the eye (hemorrhage, retinal detachment) may occur at higher dosages. Rats fed dietary doses of 2.5 mg/kg/day over 2 years did not exhibit signs of toxicity other than reduced food intake and decreased growth. In another study using rats, oral doses of 4 mg/kg/day over 2 years produced no behavioral or other changes in general condition. At this dose level no evidence of change in the kidneys, liver, or myocardium (heart muscle) were seen. This dosage (but not 2 mg/kg/day) caused changes in lung tissues. Repeated or prolonged dermal contact may cause inflammation of the skin, and, at high doses, systemic effects in other parts of the body. These may include damage to the kidneys. Chronic exposure may damage skin, which may increase the permeability of the skin to foreign compounds.

- **Reproductive effects:** Diquat dibromide generally did not reduce fertility when tested in experimental animals. Rats receiving 1.25 mg/kg/day decreased their food intake and showed slowed growth, but had unchanged reproduction. Fertility was reduced in male mice given diquat dibromide during different stages of sperm formation. Neither fertility nor reproduction was affected in a three-generation study in rats given dietary doses of 12.5 or 25 mg/kg/day of diquat dibromide, although some growth retardation was seen at the 25 mg/kg/day dose. Based on this evidence it is unlikely that diquat dibromide will cause reproductive effects in humans under normal circumstances.
- **Teratogenic effects:** Offspring of pregnant rats given a fatal injected dose of 14 mg/kg of diquat dibromide showed evidence of skeletal defects of the collar bone, as well as little or no ear bone formation upon examination. No deformities were found in the unborn offspring of pregnant rats that were injected intraperitoneally with 0.5 mg/kg/day of diquat daily during organogenesis, the stage of fetal development in which organs are formed. Growth retardation was seen in test animals given extremely high doses of diquat. While no actual teratogenesis occurred in rats given single abdominal injections during days 7 to 14 of pregnancy, many rats did not have normal weight gain and bone formation in the unborn was decreased. It is unlikely that diquat dibromide will cause teratogenic effects in humans under normal circumstances.
- **Mutagenic effects:** There is no evidence that diquat dibromide causes permanent changes in genetic material. For example, no mutagenic effects were seen in mice given oral doses of 10 mg/kg/day for 5 days.
- **Carcinogenic effects:** An 80-week feeding study showed that dietary doses of 15 mg/kg/day of diquat did not cause tumors in rats. Likewise, dietary levels of 36 mg/kg/day for 2 years did not induce tumors in rats. Based on the evidence, it appears that diquat dibromide is not carcinogenic.
- **Organ toxicity:** In animals, diquat dibromide may affect the gastrointestinal tract, eyes, kidneys or liver, and the lungs.
- **Fate in humans and animals:** Absorption of diquat dibromide from the gut into the bloodstream is low. Oral doses are mainly metabolized within the intestines, with metabolites being excreted in the feces. Rat studies showed only a small percentage of the applied oral dose (6%) was absorbed into the bloodstream and then excreted in the urine. Dermal, inhalation, or intravenous exposure results in little processing and rapid elimination in the urine. Following subcutaneous injection in rats, excretion of about 90% of the dose occurred in the urine on the first day and almost all of the remainder on the next day. Complete elimination of

the herbicide was seen in urine and feces of rats within 4 days of administration of single oral doses of 5 to 10 mg/kg of diquat dibromide.

Ecological Effects:

- **Effects on birds:** Diquat dibromide ranges from slightly to moderately toxic to birds. The reported acute oral LD50 in young male mallards is 564 mg/kg. The oral LD50 for diquat dibromide is 200 to 400 mg/kg in hens. The 5-day dietary LC50 is about 1300 ppm in Japanese quail.
- **Effects on aquatic organisms:** Diquat dibromide is moderately to practically nontoxic to fish and aquatic invertebrates. The 8-hour LC50 for diquat dibromide is 12.3 mg/L in rainbow trout and 28.5 mg/L in Chinook salmon. The 96-hour LC50 is 16 mg/L in northern pike, 20.4 mg/L in fingerling trout, 245 mg/L in bluegill, 60 mg/L in yellow perch, and 170 mg/L in black bullhead. Research indicates that yellow perch suffer significant respiratory stress when herbicide concentrations in the water are similar to those normally present during aquatic vegetation control programs. There is little or no bioconcentration of diquat dibromide in fish.
- **Effects on other organisms:** Diquat dibromide is not toxic to honey bees. Since diquat dibromide is a nonselective herbicide, it may present a danger to non-target plant species. Cows are particularly sensitive to the toxic effects of this material.

Environmental Fate:

- **Breakdown in soil and groundwater:** Diquat dibromide is highly persistent, with reported field half-lives of greater than 1000 days. It is very well sorbed by soil organic matter and clay. Although it is water soluble, its capacity for strong adsorption to soil particles suggest that it will not easily leach through the soil, be taken up by plants or soil microbes, or broken down by sunlight (photochemical degradation). Field and laboratory tests show that diquat usually remains in the top inch of soil for long periods of time after it is applied.
- **Breakdown in water:** Studies on the erosion of diquat-treated soils near bodies of water indicate that diquat dibromide stays bound to soil particles, remaining biologically inactive in surface waters, such as lakes, rivers, and ponds. When diquat dibromide is applied to open water, it disappears rapidly because it binds to suspended particles in the water. Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation and sunlight play roles in the breakdown of the compound. At 22 days after a weed infested artificial lake was treated, only 1% of the applied diquat dibromide remained in the water and 19% was adsorbed to sediments.
- **Breakdown in vegetation:** Diquat dibromide is rapidly absorbed into the leaves of plants, but usually kills the plant tissues necessary for translocation too quickly to allow movement to other parts of the plant. The herbicide interferes with cell respiration, the process by which plants produce energy. Diquat dibromide is broken down on the plant surface by photochemical degradation. It is rapidly absorbed by aquatic weeds from the surrounding water and concentrated in the plant tissue. Thus, even low concentrations of the herbicide can control aquatic weeds.

Physical Properties:

- **Appearance:** Technical diquat dibromide, which is greater than 95% pure, forms white to yellow crystals.
- **Chemical Name:** 1,1'-ethylene-2,2'-bipyridyldiylium dibromide salt
- **CAS Number:** 85-00-7
- **Molecular Weight:** 344.06
- **Water Solubility:** 700,000 mg/L @ 20 C; v.s.
- **Solubility in Other Solvents:** i.s. in nonpolar solvents such as chloroform, diethyl ether, and petroleum ether [1]; s.s in alcohol and hydroxylic solvents
- **Melting Point:** Decomposes above 300 C
- **Vapor Pressure:** Negligible @ 20 C
- **Partition Coefficient:** -4.6021
- **Adsorption Coefficient:** 1,000,000 (estimated)

Exposure Guidelines:

- **ADI:** 0.002 mg/kg/day
- **MCL**: 0.02 mg/L
- **RfD:** 0.0022 mg/kg/day
- **PEL:** Not Available
- **HA**: Not Available
- **TLV**: 0.1 mg/m3 (8-hour) (respirable fraction)

Basic Manufacturer:
Zeneca Ag Products
1800 Concord Pike
Wilmington, DE 19897

- **Phone:** 800-759-4500
- **Emergency:** 800-759-2500

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

Glyphosate

Trade and Other Names: Trade names for products containing glyphosate include Gallup, Landmaster, Pondmaster, Ranger, Roundup, Rodeo, and Touchdown. It may be used in formulations with other herbicides.

Regulatory Status: Glyphosate acid and its salts are moderately toxic compounds in EPA toxicity class II. Labels for products containing these compounds must bear the Signal Word **WARNING**. Glyphosate is a General Use Pesticide (GUP).

Chemical Class: Not Available

Introduction: Glyphosate is a broad-spectrum, nonselective systemic herbicide used for control of annual and perennial plants including grasses, sedges, broad-leaved weeds, and woody plants. It can be used on non-cropland as well as on a great variety of crops. Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders. The information presented here refers to the technical grade of the acid form of glyphosate, unless otherwise noted.

Formulation: Glyphosate itself is an acid, but it is commonly used in salt form, most commonly the isopropylamine salt. It may also be available in acidic or trimethylsulfonium salt forms. It is generally distributed as water-soluble concentrates and powders.

Toxicological Effects:

- **Acute toxicity:** Glyphosate is practically nontoxic by ingestion, with a reported acute oral LD50 of 5600 mg/kg in the rat. The toxicities of the technical acid (glyphosate) and the formulated product (Roundup) are nearly the same. The oral LD50 for the trimethylsulfonium salt is reported to be approximately 750 mg/kg in rats, which indicates moderate toxicity. Formulations may show moderate toxicity as well (LD50 values between 1000 mg/kg and 5000 mg/kg) [58]. Oral LD50 values for glyphosate are greater than 10,000 mg/kg in mice, rabbits, and goats. It is practically nontoxic by skin exposure, with reported dermal LD50 values of greater than 5000 mg/kg for the acid and isopropylamine salt. The trimethylsulfonium salt has a reported dermal LD50 of greater than 2000 mg/kg. It is reportedly not irritating to the skin of rabbits, and does not induce skin sensitization in guinea pigs. It does cause eye irritation in rabbits. Some formulations may cause much more extreme irritation of the skin or eyes. In a number of human volunteers, patch tests produced no visible skin changes or sensitization. The reported 4-hour rat inhalation LC50 values for the technical acid and salts were 5 to 12 mg/L, indicating moderate toxicity via this route. Some formulations may show high acute inhalation toxicity. While it does contain a phosphatyl functional group, it is not structurally similar to organophosphate pesticides which contain organophosphate esters, and it does not significantly inhibit cholinesterase activity.
- **Chronic toxicity:** Studies of glyphosate lasting up to 2 years, have been conducted with rats, dogs, mice, and rabbits, and with few exceptions no effects were observed.

- For example, in a chronic feeding study with rats, no toxic effects were observed in rats given doses as high as 400 mg/kg/day. Also, no toxic effects were observed in a chronic feeding study with dogs fed up to 500 mg/kg/day, the highest dose tested.
- **Reproductive effects:** Laboratory studies show that glyphosate produces reproductive changes in test animals very rarely and then only at very high doses (over 150 mg/kg/day). It is unlikely that the compound would produce reproductive effects in humans.
- **Teratogenic effects:** In a teratology study with rabbits, no developmental toxicity was observed in the fetuses at the highest dose tested (350 mg/kg/day). Rats given doses up to 175 mg/kg/day on days 6 to 19 of pregnancy had offspring with no teratogenic effects, but other toxic effects were observed in both the mothers and the fetuses. No toxic effects to the fetuses occurred at 50 mg/kg/day. Glyphosate does not appear to be teratogenic.
- **Mutagenic effects:** Glyphosate mutagenicity and genotoxicity assays have been negative. These included the Ames test, other bacterial assays, and the Chinese Hamster Ovary (CHO) cell culture, rat bone marrow cell culture, and mouse dominant lethal assays. It appears that glyphosate is not mutagenic.
- **Carcinogenic effects:** Rats given oral doses of up to 400 mg/kg/day did not show any signs of cancer, nor did dogs given oral doses of up to 500 mg/kg/day or mice fed glyphosate at doses of up to 4500 mg/kg/day. It appears that glyphosate is not carcinogenic.
- **Organ toxicity:** Some microscopic liver and kidney changes, but no observable differences in function or toxic effects, have been seen after lifetime administration of glyphosate to test animals.
- **Fate in humans and animals:** Glyphosate is poorly absorbed from the digestive tract and is largely excreted unchanged by mammals. At 10 days after treatment, there were only minute amounts in the tissues of rats fed glyphosate for 3 weeks [98]. Cows, chickens, and pigs fed small amounts of glyphosate had undetectable levels (less than 0.05 ppm) in muscle tissue and fat. Levels in milk and eggs were also undetectable (less than 0.025 ppm). Glyphosate has no significant potential to accumulate in animal tissue.

Ecological Effects:

- **Effects on birds:** Glyphosate is slightly toxic to wild birds. The dietary LC50 in both mallards and bobwhite quail is greater than 4500 ppm.
- **Effects on aquatic organisms:** Technical glyphosate acid is practically nontoxic to fish and may be slightly toxic to aquatic invertebrates. The 96-hour LC50 is 120 mg/L in bluegill sunfish, 168 mg/L in harlequin, and 86 mg/L in rainbow trout. The reported 96-hour LC50 values for other aquatic species include greater than 10 mg/L in Atlantic oysters, 934 mg/L in fiddler crab, and 281 mg/L in shrimp. The 48-hour LC50 for glyphosate in Daphnia (water flea), an important food source for freshwater fish, is 780 mg/L. Some formulations may be more toxic to fish and aquatic species due to differences in toxicity between the salts and the parent acid or to surfactants used in the formulation. There is a very low potential for the compound to build up in the tissues of aquatic invertebrates or other aquatic organisms.
- **Effects on other organisms:** Glyphosate is nontoxic to honeybees. Its oral and dermal LD50 is greater than 0.1 mg/ bee. The reported contact LC50 values for earthworms in soil are greater than 5000 ppm for both the glyphosate trimethylsulfonium salt and Roundup.

Environmental Fate:

- **Breakdown in soil and groundwater:** Glyphosate is moderately persistent in soil, with an estimated average half-life of 47 days. Reported field half-lives range from 1 to 174 days. It is strongly adsorbed to most soils, even those with lower organic and clay content. Thus, even though it is highly soluble in water, field and laboratory studies show it does not leach appreciably, and has low potential for runoff (except as adsorbed to colloidal matter). One estimate indicated that less than 2% of the applied chemical is lost to runoff. Microbes are primarily responsible for the breakdown of the product, and volatilization or photodegradation losses will be negligible.
- **Breakdown in water:** In water, glyphosate is strongly adsorbed to suspended organic and mineral matter and is broken down primarily by microorganisms. Its half-life in pond water ranges from 12 days to 10 weeks.
- **Breakdown in vegetation:** Glyphosate may be translocated throughout the plant, including to the roots. It is extensively metabolized by some plants, while remaining intact in others.

Physical Properties:

- **Appearance:** Glyphosate is a colorless crystal at room temperature.
- **Chemical Name:** N-(phosphonomethyl) glycine
- **CAS Number:** 1071-83-6
- **Molecular Weight:** 169.08
- **Water Solubility:** 12,000 mg/L @ 25 C
- **Solubility in Other Solvents:** i.s. in common organics (e.g., acetone, ethanol, and xylene) [1]
- **Melting Point:** 200 C
- **Vapor Pressure:** negligible
- **Partition Coefficient:** -3.2218 - -2.7696
- **Adsorption Coefficient:** 24,000 (estimated)

Exposure Guidelines:

- **ADI:** 0.3 mg/kg/day
- **MCL**: Not Available
- **RfD:** 0.1 mg/kg/day
- **PEL:** Not Available
- **HA**: 0.7 mg/L (lifetime)
- **TLV**: Not Available

Basic Manufacturer:

Monsanto Company
800 N. Lindbergh Blvd.
St. Louis, MO 63167

- **Phone:** 314-694-6640
- **Emergency:** 314-694-4000

Barnyard Grass

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

2,4-D

Trade and Other Names: 2,4-D is used in many commercial products. Commercial names for products containing 2,4-D include Aqua-Kleen, Barrage, Lawn-Keep, Malerbane, Planotox, Plantgard, Savage, Salvo, Weedone, and Weedtrine-II.

Regulatory Status: 2,4-D is a General Use Pesticide (GUP) in the U.S. The diethylamine salt is toxicity class III- slightly toxic orally, but toxicity class I- highly toxic by eye exposure. It bears the Signal Word **DANGER - POISON** because 2,4-D has produced serious eye and skin irritation among agricultural workers.

Chemical Class: phenoxy compound

Introduction: There are many forms or derivatives of 2,4-D including esters, amines, and salts. Unless otherwise specified, this document will refer to the acid form of 2,4-D. 2,4-D, a chlorinated phenoxy compound, functions as a systemic herbicide and is used to control many types of broadleaf weeds. It is used in cultivated agriculture, in pasture and rangeland applications, forest management, home, garden, and to control aquatic vegetation. It may be found in emulsion form, in aqueous solutions (salts), and as a dry compound.

The product Agent Orange, used extensively throughout Vietnam, was about 50% 2,4-D. However, the controversies associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2,4,5-T component of the defoliant.

Formulation: It may be found in emulsion form, in aqueous solutions (salts), and as a dry compound.

Toxicological Effects:

- **Acute toxicity:** The acid form is of slight to moderate toxicity. The oral LD50 of 2,4-D ranges from 375 to 666 mg/kg in the rat, 370 mg/kg in mice, and from less than 320 to 1000 mg/kg in guinea pigs. The dermal LD50 values are 1500 mg/kg in rats and 1400 mg/kg in rabbits, respectively. In humans, prolonged breathing of 2,4-D causes coughing, burning, dizziness, and temporary loss of muscle coordination. Other symptoms of poisoning can be fatigue and weakness with possible nausea. On rare occasions following high levels of exposure, there can be inflammation of the nerve endings with muscular effects.
- **Chronic toxicity:** Rats given high amounts, 50 mg/kg/day, of 2,4-D in the diet for 2 years showed no adverse effects. Dogs fed lower amounts in their food for 2 years died, probably because dogs do not excrete organic acids efficiently. A human given a total of 16.3 g in 32 days therapeutically, lapsed into a stupor and showed signs of incoordination, weak reflexes, and loss of bladder control.
- **Reproductive effects:** High levels of 2,4-D (about 50 mg/kg/day) administered orally to pregnant rats did not cause any adverse effects on birth weights or litter size. Higher doses (188 mg/kg/day) resulted in fetuses with abdominal cavity bleeding and increased mortality. DNA synthesis in the testes was significantly inhibited when mice were fed large amounts (200 mg/kg/day) of 2,4-D. The evidence suggests that if 2,4-D causes reproductive effects in animals, this only occurs at very high doses. Thus reproductive problems associated with 2,4-D are unlikely in humans under normal circumstances.

- **Teratogenic effects:** 2,4-D may cause birth defects at high doses. Rats fed 150 mg/kg/day on days 6 to 15 of pregnancy had offspring with increased skeletal abnormalities, such as delayed bone development and wavy ribs. This suggests that 2,4-D exposure is unlikely to be teratogenic in humans at expected exposure levels.
- **Mutagenic effects:** 2,4-D has been very extensively tested and was found to be non-mutagenic in most systems. 2,4-D did not damage DNA in human lung cells. However, in one study, significant effects occurred in chromosomes in cultured human cells at low exposure levels. The data suggest that 2,4-D is not mutagenic or has low mutagenic potential.
- **Carcinogenic effects:** 2,4-D fed to rats for 2 years caused an increase in malignant tumors. Female mice given a single injection of 2,4-D developed cancer (reticulum-cell sarcomas). Another study in rodents shows a low incidence of brain tumors at moderate exposure levels (45 mg/kg/day) over a lifetime. However, a number of questions have been raised about the validity of this evidence and thus about the carcinogenic potential of 2,4-D. In humans, a variety of studies give conflicting results. Several studies suggest an association of 2,4-D exposure with cancer. An increased occurrence of non-Hodgkin's lymphoma was found among a Kansas and Nebraska farm population associated with the spraying of 2,4-D. Other studies done in New Zealand, Washington, New York, Australia, and on Vietnam veterans from the U.S. were all negative. There remains considerable controversy about the methods used in the various studies and their results. Thus, the carcinogenic status of 2,4-D is not clear.
- **Organ toxicity:** Most symptoms of 2,4-D exposure disappear within a few days, but there is a report of liver dysfunction from long-term exposure.
- **Fate in humans and animals:** The absorption of 2,4-D is almost complete in mammals after ingestion and nearly all of the dose is excreted in the urine. The compound is readily absorbed through the skin and lungs. Men given 5 mg/kg excreted about 82% of the dose as unchanged 2,4-D. The half-life is between 10 and 20 hours in living organisms. There is no evidence that 2,4-D accumulates to significant level in mammals or in other organisms [20]. Between 6 and 8 hours after doses of 1 mg/kg, peak concentrations of 2,4-D were found in the blood, liver, kidney, lungs, and spleen of rats. There were lower levels in muscle and brain. After 24 hours, there were no detectable tissue residues. Only traces of the compound have been found in the milk of lactating animals for 6 days following exposure. 2,4-D passes through the placenta in pigs and rats. In rats, about 20% was detected in the uterus, placenta, fetus, and amniotic fluid. Chickens given moderate amounts of 2,4-D in drinking water from birth to maturity had very low levels of the compound in eggs.

Ecological Effects:

- **Effects on birds:** 2,4-D is slightly toxic to wildfowl and slightly to moderately toxic to birds. The LD50 is 1000 mg/kg in mallards, 272 mg/kg in pheasants, and 668 mg/kg in quail and pigeons.
- **Effects on aquatic organisms:** Some formulations of 2,4-D are highly toxic to fish while others are less so. For example, the LC50 ranges between 1.0 and 100 mg/L in cutthroat trout, depending on the formulation used. Channel catfish had less than 10% mortality when exposed to 10 mg/L for 48 hours. Green sunfish, when exposed to 110 mg/L for 41 hours, showed no effect on swimming response. Limited studies indicate a half-life of less than 2 days in fish and oysters. Concentrations of 10 mg/L for 85 days did not adversely affect the survival of adult

Dungeness crabs. For immature crabs, the 96-hour LC50 is greater than 10 mg/L, indicating that 2,4-D is only slightly toxic. Brown shrimp showed a small increase in mortality at exposures of 2 mg/L for 48 hours.
- **Effects on other organisms:** Moderate doses of 2,4-D severely impaired honeybees brood production. At lower levels of exposure, exposed bees lived significantly longer than the controls. The honeybee LD50 is 0.0115 mg/bee.

Environmental Fate:
- **Breakdown in soil and groundwater:** 2,4-D has low soil persistence. The half-life in soil is less than 7 days. Soil microbes are primarily responsible for its disappearance. Despite its short half-life in soil and in aquatic environments, the compound has been detected in groundwater supplies in at least five States and in Canada. Very low concentrations have also been detected in surface waters throughout the U.S.
- **Breakdown in water:** In aquatic environments, microorganisms readily degrade 2,4-D. Rates of breakdown increase with increased nutrients, sediment load, and dissolved organic carbon. Under oxygenated conditions the half-life is 1 week to several weeks.
- **Breakdown in vegetation:** 2,4-D interferes with normal plant growth processes. Uptake of the compound is through leaves, stems, and roots. Breakdown in plants is by a variety of biological and chemical pathways. 2,4-D is toxic to most broad leaf crops, especially cotton, tomatoes, beets, and fruit trees.

Physical Properties:
- **Appearance:** 2,4-D is a white powder.
- **Chemical Name:** (2,4-dichlorophenoxy)acetic acid
- **CAS Number:** 94-75-7
- **Molecular Weight:** 221.04
- **Water Solubility:** 900 mg/L @ 25 C (acid)
- **Solubility in Other Solvents:** ethanol v.s.; diethyl ether v.s.; toluene s.; xylene s.
- **Melting Point:** 140.5 C [6]
- **Vapor Pressure:** 0.02 mPa @ 25 C (acid)
- **Partition Coefficient:** 2.81
- **Adsorption Coefficient:** 20 (acid)

Exposure Guidelines:
- **ADI:** 0.3 mg/kg/day
- **MCL**: 0.07 mg/L
- **RfD:** 0.01 mg/kg/day
- **PEL:** 10 mg/m3 (8-hour)
- **HA**: Not Available
- **TLV**: Not Available

Basic Manufacturer:
Rhone-Poulenc Ag. Co.
P.O. Box 12014
2 T.W. Alexander Dr.
Research Triangle Park, NC 27709
- **Phone:** 919-549-2000
- **Emergency:** 800-334-7577

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Triclopyr - (Trade name Renovate3®).

There are two formulations of triclopyr. It is the TEA formation of triclopyr that is registered for use in aquatic or riparian environments. Triclopyr, applied as a liquid, is a relatively fast-acting, systemic, selective herbicide used for the control of Eurasian watermilfoil and other broad-leaved species such as purple loosestrife. Triclopyr can be effective for spot treatment of Eurasian watermilfoil and is relatively selective to Eurasian watermilfoil when used at the labeled rate.

Many native aquatic species are unaffected by triclopyr. Triclopyr is very useful for purple loosestrife control since native grasses and sedges are unaffected by this herbicide. When applied directly to water, Ecology has imposed a 12-hour swimming restriction to minimize eye irritation.

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Always follow he label's instructions for the proper pesticide or herbicide treatment. Protect yourself and write down everything you do and use.

Imazapyr (Trade name Habitat®).

This systemic broad spectrum herbicide, applied as a liquid, is used to control emergent plants like spartina, reed canarygrass, and phragmites and floating-leaved plants like water lilies. Imazapyr does not work on underwater plants such as Eurasian watermilfoil. Although imazapyr is a broad spectrum, non-selective herbicide, a good applicator can somewhat selectively remove targeted plants by focusing the spray only on the plants to be removed.

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Fluridone

Trade names for fluridone products include: Sonar® and Avast!®). Fluridone is a slow-acting systemic herbicide used to control Eurasian watermilfoil and other underwater plants. It may be applied as a pellet or as a liquid. Fluridone can show good control of submersed plants where there is little water movement and an extended time for the treatment. Its use is most applicable to whole-lake or isolated bay treatments where dilution can be minimized. It is not effective for spot treatments of areas less than five acres. It is slow-acting and may take six to twelve weeks before the dying plants fall to the sediment and decompose.

When used to manage Eurasian watermilfoil, fluridone is applied several times during the spring/summer to maintain a low, but consistent, concentration in the water. Although fluridone is considered to be a broad spectrum herbicide, when used at very low concentrations, it can be used to selectively remove Eurasian watermilfoil. Some native aquatic plants, especially pondweeds, are minimally affected by low concentrations of fluridone.

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Procedures for Calculating Lake Volumes for Proposed Fall Fluridone Treatments

This is the standard procedure used to calculate the volume of water within a lake and to determine the appropriate application amount of aqueous solution of fluridone (Sonar A.S.® and AVAST!™). The goal of this procedure is to achieve rapid and uniform distribution of a given fluridone concentration by treating water within the 0-5 foot depth contour and those areas with depth greater than 5 feet separately with different amounts of fluridone.

This procedure determines the amount of product necessary to treat an entire lake at a given concentration. An example is presented for calculating a concentration of 5 ppb fluridone applied to a lake that has a surface area (0-foot) of 239 acres, an area of 189 acres at the 5-foot depth contour, and 71 acres at the 10-foot depth contour. A1, A2, and A3 represent the areas for those depth contours, respectively.

Volume Calculations
STEPS
1. Determine the surface acres of the 0-, 5-, and 10-foot depth contours.
Example: 0-, 5-, and 10-foot depth contours are 239, 189, and 71 acres, respectively.
2. Use the following formula for calculating the volume of a frustum for the lake between the surface (0-foot) and 5-foot depth contours.

V (acre-feet) = h/3 (A1 + A2 + [sq. rt. (A1 x A2)])

Where: V = volume, h = height of the water column in feet, A1 = area of the lake surface in acres, and A2 = area of the 5-foot contour in acres.
Example: The volume of water to the 5-foot depth contour = 5/3 (239 + 189 + [sq. rt. (239 x 189)]) = 1069 acre-feet
3. Multiply the area of the 5-foot contour by 5 feet.
Example: 189 acres x 5 feet = 945 acre-feet
4. Subtract Step 3 from Step 2 to calculate the volume of water in the 0- to 5-foot "donut" area. Example: 1069 acre-feet – 945 acre-feet = 124 acre-feet
5. Multiply Step 4 by 2.72 (pounds of the active ingredient fluridone in a one part per million solution in an acre-foot of water). Then multiply that value by the target concentration in parts per **million,** not in parts per billion. One quart of product (Sonar A.S.® or AVAST!™) contains one pound of the active ingredient fluridone.
Example: At 5 ppb; 124 acre-feet x 2.72 x 0.005 = 1.7 pounds of fluridone or 1.7 quarts of product (Sonar A.S.® or AVAST!™).
6. Enter the 5- and 10-foot depth contour areas into the volume formula for a frustum as presented in Step 2 to find the volume of water between the 5- to10-foot contours.
Example: V = 5/3 (189 + 71 + [sq. rt. of (189 x 71)]) = 628 acre-feet
Repeat Step 6 to determine the volumes between the various depth contours.
Example: 10-20 feet, 20-30 feet, etc.
7. Add the values calculated for Steps 3 and Step 6 (for each depth contour volume) to determine the volume of the "donut hole" area from the 5-foot depth contour to the lake bottom.
Example: (628 acre-feet + 945 acre-feet + (10-20 foot depth in acre-feet) + (20-30 foot depth in acre-feet) etc. = 1573 acre feet
8. Multiply Step 7 by 2.72 (pounds of the active ingredient fluridone in a one part per million solution in an acre-foot of water). Then multiply that value by the target concentration in parts per **million,** not in parts per billion. One quart of product (Sonar A.S.® or AVAST!™) contains one pound of the active ingredient fluridone. This quantity of product is then distributed in the greater than 5 foot "donut hole" area.
Example: At 5 ppb; 1573 acre-feet x 2.72 x 0.005 = 21.4 pounds of fluridone or 21.4 quarts of product (Sonar A.S.® or AVAST!™).
9. Add the values in Steps 5 and 8 to obtain the total amount of product necessary to treat the lake to a depth of 10 feet at a given concentration.
Example: At 5 ppb; 1.7 quarts + 21.4 quarts = 23.1 quarts of product.

Product Distribution
Distribute the product in the 0- to 5-foot depth contour "donut" area by zigzagging the boat within the water that is 0 to 5 feet deep as evenly as possible. Distribute the product in the water deeper than 5 feet (the "donut hole") in a crisscross pattern.

Algaecide Section

Copper Sulfate

Most species of algae can be controlled with very low concentrations of copper sulfate. It is available in crystalline nuggets the size of rock salt or as a finely ground "snow" grade (Figure 1). The recommended treatment rate is 2.7 pounds per acre-foot of water. Acre-feet is a volume measurement of the pond. It is determined by multiplying average depth (feet) X surface area (acres). For more information on calculating measurements, see the prior section in this book. When uniformly applied, this will result in a 1 part per million (ppm) concentration throughout the volume of the pond. For very hard water (more than 12 grains or 200 parts per million of hardness), this rate should be doubled.

Figure 1. Copper sulfate is available as nuggets (left) or as finely ground crystals.

The method of application will determine what size of copper sulfate crystals to purchase. The important principle to keep in mind is that actual contact of the copper sulfate with the algae is necessary in order to achieve satisfactory control. For best results, dissolve copper sulfate in water and spray it directly on floating algal mats or on the water surface above submerged algae.

Finely ground, "snow grade" copper sulfate is best for this method, as it dissolves easier. Mix the desired amount of copper sulfate with enough water to cover the area to be treated, and apply with a sprayer or bucket and dipper. Because copper is corrosive to galvanized metal, application equipment and mixing containers should be made of plastic or stainless steel.

In large ponds and when spray equipment is not available, it may be easier to treat with copper sulfate by placing the larger crystals of this chemical in a burlap bag and towing the bag through the water until all the crystals have been dissolved in the area to be treated. One application of copper sulfate is unlikely to provide season-long control.

Re-treatment may be necessary at 3-4 week intervals. There are no water-use restrictions associated with the use of copper sulfate. When applied at the proper rate, the water may be used immediately for swimming, drinking, fishing, irrigation and livestock.

However, since copper sulfate has a metallic odor, pond owners may want to suspend drinking, swimming and livestock watering uses for 12 hours.

A 25% copper compound has been used for years as an algaecide. This product is effective against all forms of algae including: filamentous, planktonic, and branched algae. The crystal form is most effective on bottom mats while the fine crystal may be easily spread or dissolved in water. Copper sulfate is less effective in hard water than chelated copper products. This product is corrosive to metal equipment and toxic to fish in soft water. Normal application rate is 2.7 pounds per acre foot of water treated. Effective for control of swimmers itch with special application methods. There are no restrictions on water usage following application.

Copper Chelate
Copper is also available in a chelated, or buffered, formulation, which is manufactured as a liquid or granule. This provides some advantages during application. The liquid form needs only to be mixed with water and sprayed out over the pond surface; there are no crystals to dissolve. The granular formulation consists of a clay granule impregnated with copper chelate.

As the granule breaks down, the copper is released into the water. This formulation is especially useful when spot treatment is desirable. Granules are best suited for application early in the growing season because of the time required (2-3 weeks) for them to dissolve and release the chemical. There are no water-use restrictions associated with either formulation of copper chelate.

Captain


A 9% chelated copper algaecide for use in potable water reservoirs; farm, fish, and fire ponds; lakes; and fish hatcheries. Captain provides effective control of planktonic algae, including: Anabaena, Aphanizomenon, and Microcystis; filamentous algae, including; Spirogyra, Cladophora, Phizoclonium, and Hydrodictyon; and branched algae, including: Chara and Nitella. Application rates ranges from 0.6 to 1.2 gallons per acre foot of water treated.

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Cutrine Plus


A 9% chelated copper algaecide for use in lakes, potable water reservoirs, farm ponds, fish and industrial ponds, fish hatcheries and raceways, crop and non-crop irrigation conveyance systems, ditches, canals, and laterals. Cutrine Plus, under field conditions, is effective in controlling a broad range of algae including Chara, Spirogyra, Cladophora, Vaucheria, Ulothrix, Microcystis, and Oscillatoria. Effective in hard water. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Application rates range from 0.6 to 1.2 gallons per acre foot of water treated.

Cutrine Plus Granular

A 3.7% granular chelated copper algaecide ideally suited for treatment of bottom growing algae including Chara and Nitella and spot treatments along docks, beaches, boat launches, and fishing areas. This formulation helps control growth before it reaches the surface. Cutrine Plus Granular is registered for use in lakes, potable water reservoirs, farm and fish ponds, fish hatcheries, and golf course water hazards. Treated water may be used for swimming, fishing, drinking, livestock watering, or irrigation immediately after treatment. Spread as evenly as possible over treatment area at a rate of 1 pound per 750 square feet or 60 pounds per surface acre.

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Cutrine Plus Ultra

This formulation has the same active chelated copper content as Cutrine Plus with the addition of a non-ionic surfactant. Cutrine Plus Ultra is more effective against hard to control algae.

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GreenClean

GreenClean is a granular peroxide based product. This product is new to the industry for the 2004 season. The mode of action is oxidation, which provides immediate control of algae, and it releases oxygen as it works. GreenClean is one of the only non-copper based algaecides currently on the market. GreenClean can be applied by broadcasting, as a dissolved liquid, or as a subsurface application. Application rates range from 3-170 pounds per acre-foot depending on the amount of algae growth.

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Stocktrine

A chelated copper algaecide for use in small ponds, tanks, and troughs for control of filamentous and planktonic algae. Popular for use in small decorative pools. Easy to calculate and measure appropriate amount of material to be used in small volumes of water. Dosage rate is one ounce per 250 gallons. May be toxic to some ornamental fish.

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Evening Primrose

Bluegrass

Aquatic Herbicide Section

Aqua-Kleen

Aqua-Kleen is a granular formulation of 2,4-D which has been used for years for selective control of noxious aquatic plants, including water milfoil. This aquatic herbicide can also be used to manage aquatic plants such as coontail, water stargrass, spatterdock, and water lilies when considered nuisance. Aqua-Kleen does not affect most plants considered beneficial by water resource and fisheries managers; therefore, this herbicide works very well for spot treatments without impacting untreated areas of the water body. Suspension of water use for irrigation and domestic use based on testing for residual.

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Aqua-Pro

A concentrated systemic type herbicide infective against a variety of emergent aquatic and terrestrial grasses, broadleaf weeds, brush, and cattatils in and around aquatic sites, including lakes, rivers, streams, ponds, seeps, irrigation and drainage ditches, canals, and reservoirs. There is no restriction on the use of water for irrigation, recreation, or domestic purposes following application as described on the label. This product must be used with a non-ionic surfactant approved for the application site. We use Cide Kick II or Silenergy.

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Diquat dibromide

This is a contact herbicide that will control some, but not all, species of filamentous algae. It is applied by pouring directly from the container or by diluting with water and injecting below the water surface. For best results, it should be applied before algae growth reaches the surface. Diquat dibromide should not be used in muddy water. There are water-use restrictions associated with this material. Read the label.

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Aquathol K

A liquid concentrate soluble in water which is effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. This product may be used in irrigation and drainage canals, ponds, and lakes. Aquathol K is a contact herbicide; consequently, do not apply before weeds are present. For best results water temperature should be at least 65°F. Restrictions on water usage following application are: livestock water, irrigation, and domestic use- 7 to 14 days; fish consumption - 3 days. Application rates range from 0.3 to 3.2 gallons/acre foot of water treated.

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Aquathol Super K

A concentrated granular herbicide effective against a broad range of aquatic plants with a wide margin of safety to fish and other aquatic life. The Super K pellets are manufactured in a manner which provides an essentially dust free material for easier application. The more concentrated formulation reduces the amount of material needed. Restrictions on water usage following application are: livestock water, irrigation, and domestic use - 7 days; fish consumption – 3 days. Application rates range from 2.2 to 22 pounds/acre foot of water treated.

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Endothall

The amine salt formulation of endothall (sold as Hydrothol 191) is labeled for algae control. It is available as a liquid or granular material. Endothall is a contact herbicide and is most effective in waters 65° F and above. Fish are extremely sensitive to this material. Read the label for water-use restrictions.

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DMA 4 IVM

An amine formulation of 2,4-D containing 46.3%(3.8 lb) active ingredient per gallon. DMA*4 IVM provides general aquatic weed control for susceptible emergent species, primarily broad-leaved plants and also controls brush and bullrushes. DMA*4 IVM is labeled for the control of water milfoil. Mix 2 to 4 quarts of DMA*4 IVM plus aquatic surfactant and drift control agent with 50-100 gallons of water per surface acre of foliage. For small areas use 2 ounces per gallon of water in sprayer. Available in 2.5 gallon containers.

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Nautique

Nautique is an effective copper based aquatic herbicide that is used to control hydrilla, naiads, brazilian elodea, widgeon grass, milfoil, sago pondweed, and horned pondweed. Nautique aquatic herbicide may be used in lakes, ponds, potable water reservoirs, ornamental ponds, golf course water hazards, fire ponds, and industrial retention basins. Water may be used immediately after treatment for swimming, fishing, livestock watering, and irrigation. Application rates range from 1.8 to 3.0 gallons per acre foot of water treated.

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Navigate

A granular formulation of 2,4-D which is effective on water milfoil, water stargrass, coontail, spatterdock, water lilies, and watershield. It is very effective in control of Eurasian watermilfoil, an aggressive, exotic species found throughout the U.S. This product is not for use in waters used for irrigation, agricultural sprays, watering dairy animals, or domestic water supplies. Recommended restrictions after application include no swimming for 1 day and no use of fish from treated waters for 3 days. Application rates vary from 100 pounds per acre for milfoil to a maximum of 200 pounds per acre for resistant plants such as spatterdock and watershield.

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Renovate 3

A systemic aquatic herbicide used for control of certain submersed, floating, and emergent aquatic plant species, including woody plants, in ponds, lakes, reservoirs, and marshes. Additional treatment sites include adjacent banks, shores, canal banks, and on non-irrigation canals which have little or no continuous outflow. Renovate 3 is an effective herbicide for water milfoil, purple loosestrife, and other "broadleaved" aquatic species. Renovate 3 will not harm "monocot" species such as cattails and grasses. Available in 2.5 gallon containers.

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Reward

A concentrated liquid aquatic herbicide effective against a wide variety of submersed, emergent, and floating aquatic plants including duckweed, naiads, and cattails. Reward poses virtually no environmental risk in aquatic applications because the herbicide concentration rapidly decreases as it is absorbed onto soil, vegetation, and organic matter. Restrictions on water usage following application: livestock consumption - 1 day; irrigation of food crops - 5 days; irrigation of turf and non-food crops- 1-3 days; human drinking - 1-3 days. The product of choice when fishing restrictions are not tolerable. Application rates: 1 to 2 gallons per surface acre.

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Sonar

An aquatic herbicide effective against a variety of submersed, emergent, and floating aquatic plants (including duckweed and watermeal). Provides excellent season-long control with an early spring application prior to or just after plant growth begins. Available in liquid and pelleted formulations. No restrictions on water use for fishing, swimming, or domestic use following application according to label instructions. Fourteen to thirty day restriction on use of treated water for irrigation following application. Application rates: Liquid: ponds - 0.16 to 1.5 quarts per acre; lakes - 0.11 to 4 quarts per acre. Pellets: ponds - 3.2 to 25 pounds per acre;, lakes - 4 to 80 pounds per acre.

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Weedtrine D

A non-volatile herbicide for use in controlling submersed and floating aquatic weeds. It is also recommended for top kill of shoreline emergent weeds and as a grass and broadleaf weed growth killer in non-crop or non-planted areas. Absorption and herbicidal action of Weedtrine D is usually quite rapid with effects visible in a few days. Application rates are 5-10 gallons per surface acre. Water should not be used for irrigation or domestic use for 5 days following treatment.

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Acknowledgement for use of the herbicide information and for more information, please contact:

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This course contains EPA's federal snd State rule requirements. Please be aware that each state implements drinking water and/or pesticide regulations that may be more stringent than EPA's or State regulations. Check with your state environmental agency for more information.

Inert Dyes

Inert dyes can be used to control algae. The color they turn the water, usually blue, reduces sunlight penetration, which in turn reduces growth of algae and submerged weeds. These dyes are not effective in water less than 2 feet deep or if the alga is floating on the water surface. Most inert dyes are labeled for all water uses except domestic drinking water supplies. Check the label.

Table 1. Aquatic Herbicides for Filamentous Algae Control (except Pithophora)

Labeled Herbicides		Waiting Period Before Water Used For:					
Trade Name	Chemical Name	Human			Animal	Irrigation	
		Drinking	Swimming	Fishing	Drinking	Turf	Food Crops
AlgaePro	Copper chelate	0 days	0 days	0 days	0 days	0 days	0 days
Aquashade, Aquashadow	(Inert dye)	Not permitted	24 hours (note 1)	0 days	0 days	0 days	0 days
Copper sulfate	Copper sulfate	0 days (note 2)	0 days (note 2)	0 days	0 days (note 2)	0 days	0 days
Cutrine Plus (liquid and granular)	Copper chelate	0 days	0 days	0 days	0 days	0 days	0 days
Diquat/ Reward (note 3)	Diquat dibromide	14 days	24 hours	0 days	14 days	14 days	14 days
Hydrothol 191	Endothall	7-14 days (note 4)	24 hours	3 days	7-14 days (note 4)	Not permitted	7-14 days (note 4)

Notes to Table 1: 1 - Wait for complete dispersal before swimming.
2 - No required waiting period. 24-hour waiting period recommended to allow for dissipation of metallic odor.
3 - Controls some species of algae: *Spirogyra* and *Pithophora*.
4 - Varies by application rate used.
5 - Copper is toxic to fish eggs and fish fry.
6 - Production of this material has been terminated, but it may be purchased and used until supplies are exhausted.

Table 1. (Continued) Aquatic Herbicides for Filamentous Algae Control (except Pithophora)					
Labeled Herbicides		**Characteristics**			
Trade Name	**Chemical Name**	**Min/Max Water Temp.**	**Biodegradable**	**Fish Toxicity at Recommended Rates**	**Observable Effects**
AlgaePro	Copper chelate	60 F/None	Partial	note 5	7-10 days
Aquashade, Aquashadow	(Inert dye)	None	Yes	No	Varies
Copper sulfate	Copper sulfate	60 F/None	No	note 5	3-5 days
Cutrine Plus (liquid and granular)	Copper chelate	60 F/None	Partial	note 5	7-10 days
Diquat/ Reward (note 3)	Diquat dibromide	60 F/None	Adheres to soil	No	7 days
Hydrothol 191	Endothall	65 F/None	Yes	Yes	3-14 days

Notes to Table 1: 1 - Wait for complete dispersal before swimming.
2 - No required waiting period. 24-hour waiting period recommended to allow for dissipation of metallic odor.
3 - Controls some species of algae: *Spirogyra* and *Pithophora*.
4 - Varies by application rate used.
5 - Copper is toxic to fish eggs and fish fry.
6 - Production of this material has been terminated, but it may be purchased and used until supplies are exhausted.

Copper-Resistant Algae

One form of filamentous algae, Pithophora, can be especially troublesome because it is resistant to normal applications of copper compounds. Although it is not widespread, scattered reports of Pithophora in ponds are received every year. If, after a normal treatment with copper sulfate, there is algae remaining that does not appear to be affected, it may be Pithophora.

Pithophora is extremely difficult to control. Its unique cell wall structure and the tight clumping of filaments inhibit the penetration by copper. Additionally, large numbers of resilient spore-like bodies, called akinetes, germinate and provide a continuous source of new plants. Partial, short term control can usually be achieved with either of the following herbicide mixtures:

	Ratio	**Application Rate of Mixture**
Cutrine Plus Liquid and Diquat/Reward	1:1	2 gallons per acre-foot
Cutrine Plus Liquid and Hydrothol 191 Liquid	2:1	1 gallon per acre-foot

Additionally, Cide-Kick, a nonionic spray adjuvant, should be added to the mixture at the rate of 1-2 gallons per surface-acre. This material acts as a cell wall penetrant to increase the effectiveness of the herbicides.

Special Precautions
Fish are extremely sensitive to Hydrothol 191. To reduce the hazard of a fish kill, start application at the shoreline and move outward so that fish can escape from treated areas. Select another product if fish toxicity is a concern.

Copper sulfate is corrosive to galvanized containers. Therefore, the solution should be mixed in wooden, earthenware, plastic, stainless steel or copper-lined containers. If a sprayer is not available, you may broadcast the solution with a plastic watering can or bucket and dipper.

If the algae is so abundant that it covers more than half of the total pond surface, a complete treatment may result in an oxygen depletion and fish kill. This hazard is greatest during very hot, overcast weather. When these conditions exist, treat only half the pond and wait 10-14 days before treating the other half.

Copper compounds applied at the recommended rates are lethal to fish eggs and some species of newly hatched fish. These materials should not be applied during spawning periods, unless it is desirable to destroy the eggs and the new hatch. Bass will begin to construct shallow depressions in the pond bottom when the water reaches 60°F. Eggs are deposited by the female and guarded by the male for 3-14 days.

Within a couple of weeks after the bass have spawned and when the water temperature reaches 70°F, bluegill and redear sunfish will be seen building nests in the shallow areas. As with the bass, the male guards the nest after the eggs have been deposited. These eggs will hatch in a few days. Bass will only spawn once in the spring, but forage fish (bluegill, redear sunfish and minnows) will spawn throughout much of the summer and some individuals may spawn several times in a single season. To avoid the application of copper compounds during the spawning season, monitor the water temperature and look for active nests in the shallow areas of the pond.

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

The Right Chemical

Will the chemical achieve the results desired? This question may seem too obvious, but it is one that is often overlooked by pond owners. For example, no single aquatic herbicide is capable of controlling all kinds of weeds that are potential pond management problems. Most chemicals used to control weeds, diseases, and other aquatic pests are expensive and are effective only on certain pest organisms. For this reason, it is important to accurately identify the aquatic pest or the water quality problem before purchasing and applying a chemical to a pond. Your county extension agent or state fisheries biologist can assist you in identifying the pest or the water quality problem.

Once you have accurately identified the problem, then select the most effective control measure. This does not mean that a chemical can or should be used to correct every pond management problem. The best approach is to consider preventive measures first. If they are not practical or do not produce the desired results, then other control methods should be considered. It is always easier and more economical to prevent a problem than to cure one. Even when preventive measures are only partially successful, they quite often facilitate the effectiveness of other control measures. Preventive measures may or may not include the use of chemicals.

Matching the management problem with an effective chemical is not enough. You must also consider the effect that chemicals may have on non-target organisms.

For example, some chemicals used to treat diseases in fish are also toxic to plants. Use of these chemicals during the summer months may cause oxygen depletion. Also, the water chemistry and its effect on the chemical may need to be considered. Some chemicals break down rapidly in the presence of sunlight, high pH, and high temperature and are less likely to be effective during the hot summer months. Be sure to consider other water uses and effects the chemical may have on them. For example, aquatic herbicides applied to a pond used for irrigation may have a disastrous effect upon the irrigated crops. Also, consider the effects the chemical may have downstream from your pond.

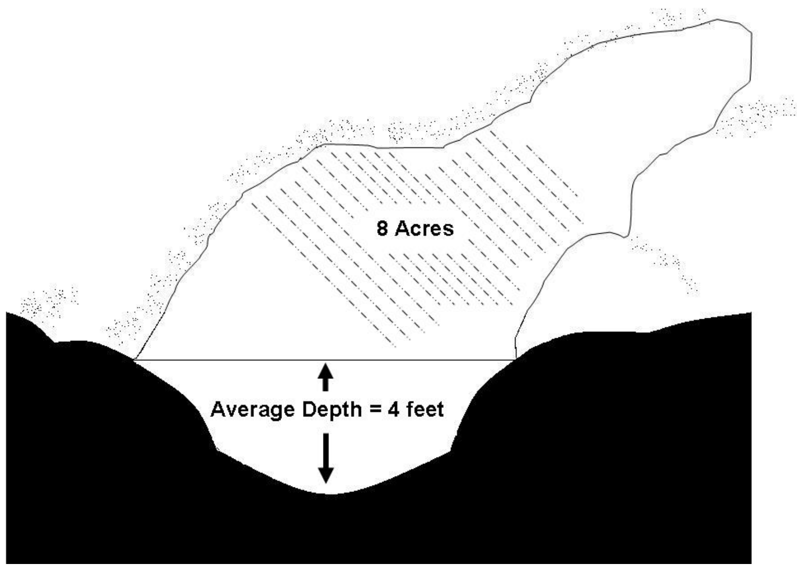
Whenever you use a chemical in a pond, it must be applied properly and all warnings and precautions concerning use must be understood and observed. Fortunately, all of this information is on the label for most chemicals approved for use in ponds. Anyone who uses a chemical in a pond should *always thoroughly read and understand the chemical label* before purchasing and applying it.

Obviously the effectiveness of some chemical treatments can be quite variable. If you are not certain of the identification of the aquatic pest or the best control method, consult your county extension agent or state fisheries biologist. Assuming you have selected the most effective chemical for use, the following information should be used to determine the proper amount to apply and to determine the best and safest way to apply it.

Calculation of Chemical Treatments Applied to Pond Water

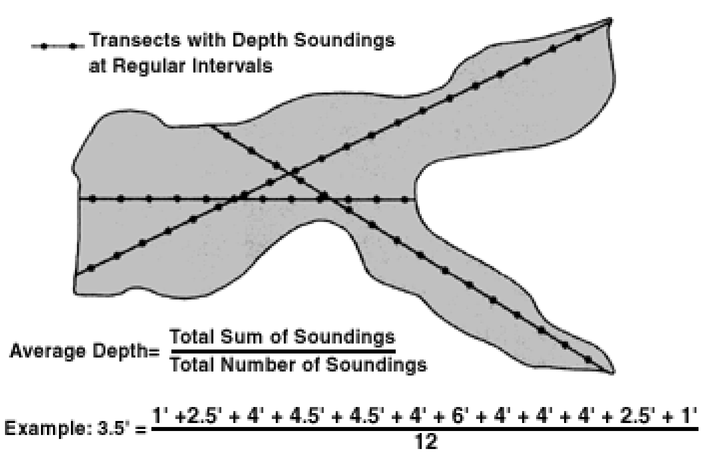
The following information is essential in computing the amount of chemical to apply to a pond: the pond water volume, the chemical formulation, and the effective concentration of the chemical needed in the pond water to correct the problem.

Pond Water Volume
Every pond owner should know the water volume of his pond. Volume can be expressed as cubic feet, cubic meters, gallons, liters, etc. However, because of the rather large numbers involved with these units, the common measure used for pond water volume is acre-feet. For example, a pond of eight surface acres with an average depth of four feet would contain 10,432,000 gallons of water. This equals 32 acre-feet of water.



An acre-foot is one surface acre one foot deep. Acre-feet are computed by multiplying the area (in acres) by the average depth (in feet). In the example above, eight surface acres times the average depth of four feet equals 32 acre-feet of water.

Most county Natural Resources Conservation Service offices can assist pond owners in determining the water volume of their ponds. The surface acreage of most ponds can also be determined by county Farm Service offices. Assuming the surface acreage of a pond is known, the following method can be used to determine the average depth of a pond. Average depth can be determined by use of a sounding line at regular intervals along several transects of the pond. Both deep and shallow area of the pond should be included in the transects.



Average depth is computed by adding all of the depth measurements and dividing by the number of measurements to get the average. The average depth multiplied by the surface area should give an accurate estimate of the pond water volume.

Know the water volume of your pond before a treatment is needed. You can lose valuable time if the determination must be made after a problem has arisen. Table 1 can be used to convert acre feet into other measures of water volume.

Table 1. Equivalents of 1 acre foot of water

1 acre-foot	= 43,560 cubic feet
	= 4,840 cubic yards
	= 326,000 gallons (approximately)
	= 2,780,000 pounds (approximately)

Chemical Formulations
Chemical formulations vary in the amount of active ingredients present. The active ingredients are the chemicals which actually kill the pest or correct the undesirable water quality problem. Inert ingredients are added to improve the convenience, safety and handling of the chemical.

For a particular chemical, the application rate is based upon the amount of active ingredient in the chemical formulation. Fortunately, the amount of active ingredients contained in the chemical formulation and the application rate are printed on most product labels. This is one reason why it is important to read the information printed on the label.

Effective Chemical Concentration
In treating a pond, chemicals are added to the water to produce an effective concentration of active ingredients that will eliminate the pest or correct the water quality problem. Desired concentrations are usually expressed as parts per million, usually written as ppm.

One part per million is equivalent to the ratio of one pound of chemical to 999,999 pounds of water or one gram of chemical to 999,999 grams of water. In other words, one part per million equals one pound or one gram in one million pounds or grams of a solution or mixture, respectively.

Notice that parts per million is a weight-to-weight relation. Units of volume cannot be used directly. This is because an equal volume of two different chemicals may have considerably different weights. For example, one cubic-foot of lead weighs much more than one cubic-foot of water.

Calculation of Pond Water Treatments
The following formula can be used to determine the amount of chemical needed to treat a pond:

Amt of Chemical = Volume x CF x ECC x AI Needed

Where:
Volume = Volume of water to be treated. Although the unit of measure can be in gallons, liters, cubic feet, cubic yards, etc., when treating ponds, the more common and easier to use expression of volume is acre-feet.

CF = Conversion factor, a figure that equals the weight of a chemical to be used to give one part per million (ppm) in a given unit volume of water. Table 2 lists conversion factors (CF) for various measures of volume. For example, select the CF that corresponds to the unit of measure used for pond volume. For example, if the pond volume is measured in acre-feet, the appropriate CF is 2.72 if the chemical weight is measured in pounds or 1,233 if weight is measured in grams.

Table 2. Conversion Factors (CF) - Weight of Chemical in One Unit Volume of Water to Give One Part Per Million ppm.

2.72 pounds per acre-foot	= 1 ppm
1,233 grams per acre-foot	= 1 ppm
0.0283 grams per cubic foot	= 1 ppm
0.0000624 pounds per cubic foot	= 1 ppm
0.0038 grams per gallon	= 1 ppm
0.0584 grains per gallon	= 1 ppm
1 milligram per liter	= 1 ppm
0.001 gram per liter	= 1 ppm
8.34 pounds per million gallons of water	= 1 ppm

ECC = Effective chemical concentration of active ingredients needed in the pond water to eliminate the pest or correct a water quality problem. This unit of measure must be in ppm. AI = The total amount of active and inert ingredients divided by the amount of active ingredients. Products, which are liquid formulations, usually list the amount of active ingredients as pounds active per gallon. For such products AI = 1 gallon divided by the pounds per gallon of active ingredients. A few chemicals are liquids in their pure form and their specific gravity must be known to calculate AI. See Example 4 to calculate AI using specific gravity.

Non-liquid formulations usually list active ingredients as a percentage of the total formulation. For nonliquid formulations, AI = 100% divided by the percentage of active ingredients.

The following examples illustrate how the equation previously mentioned can be used in calculating pond water treatments.

Example 1. How much Chemical A is needed to treat a pond that has 4 surface acres and an average depth of 3 feet with 2 ppm active ingredient? Chemical A is 100% active.

Volume	= 4 acres x 3 feet
CF	= 12 acre-feet
ECC	= 2.72 pounds (from Table 2)
AI	= 2 ppm (active ingredient needed in the water)
	= 100%
	100% (Chemical A is 100% active)

The amount of Chemical A needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (12 acre-feet x 2.72 pounds x 2 ppm x 100) / 100 = 65.3 pounds of Chemical A are needed to treat the pond.

Example 2. How much Chemical B (80 percent active) is needed to treat a pond measuring 1,000 feet long by 500 feet wide by 5 feet deep with a concentration of 0.25 ppm active ingredient?

Volume = 100 feet x 50 feet x 5 feet
= 25,000 cubic feet
CF = 0.0000624 pounds/cubic foot (from Table 2)
ECC = 0.25 ppm (active ingredient needed in the water)
AI = 100%

80%

The amount of Chemical B needed is found by substituting the above values in the formula.

Volume x CF x ECC x AI

Thus: (25,000 cu. ft. x 0.0000624 pounds/cu.ft. x 0.25 ppm x 100) / 80 = 0.49 pounds of Chemical B (80 percent) are needed to treat the pond.

Example 3. How much Chemical C (2 pounds active per gallon) is needed to treat a pond that has 6 surface acres and an average depth of 4 feet with 0.5 ppm active ingredient?

Volume = 6 acres x 4 feet
= 24 acre-feet
CF = 2.72 pounds/acre-foot (From Table 2)
ECC = 0.5 ppm (active ingredient needed in water)
AI = 1 gal.

2 lbs.

The amount of Chemical C needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (24 acre-feet x 2.72 pounds/acre-foot x 0.5 ppmx 1 gal) / 2 lbs = 16.3 gallons of Chemical C (2 lbs active/gallon) are needed to treat the pond.

Example 4. How much Chemical D is needed to treat a pond measuring 180 feet long by 90 feet wide by 4 feet deep with a concentration of 25 ppm active ingredient. Chemical D is a liquid and is 100 percent active.

Volume	= 180 feet x 90 feet x 5 feet
	= 81, 000 cubic feet
CF	= 0.0000624 pounds per cubic foot
ECC	= 25 ppm
AI	= 100%

100%

The amount of Chemical D needed is found by substituting the above values in the formula:

Volume x CF x ECC x AI

Thus: (81,000 cu. ft. x 0.0000624 pounds/cu.ft. x 25 ppm x 100) / 100 =126.4 pounds of Chemical D

However, Chemical D is a liquid and 126.4 pounds must be converted to a unit of volume. Since (ppm) parts per million is a weight-to-weight relation, it is necessary to know how Chemical D compares in weight with water. Chemical D is heavier than water, thus a smaller amount of Chemical D is needed to equal 250 ppm in water on a Chemical D to water weight-to-weight ratio. Chemical D weighs about 9 pounds per gallon and water 8.34 pounds per gallon; or Chemical D is 1.08 times as heavy as water (9 divided by 8.34). This figure is called the specific gravity (SG) of Chemical D. If the weight of Chemical D is computed in grams, the weight divided by the specific gravity equals the number of cubic centimeters required. If the weight (as in this example = 126.4 pounds) is computed in pounds, divide by 8.34 times the specific gravity to convert it to gallons. In this example the amount of Chemical D needed is:

(126.4 pounds) / (8.34 lbs/gal x 1.08 SG) = 140 gallons

Treatment Methods

Selection of the best treatment method depends upon the specific situation and the chemical used in treatment. The following treatment methods can be used.

Treatments Applied to Pond Water

1. **Surface - applied treatments**
   Contact pesticides, inorganic fertilizers, lime, and a few other water quality control chemicals are applied to ponds at a rate based upon the surface acreage of the pond - not the pond's water volume. Generally, these chemicals are either sprayed or broadcasted over the pond surface.
2. **Total water column water treatments**
   This is the most common technique of chemical treatment used in a pond. The whole volume of water (water column) in the pond is treated. The pond water volume is calculated and the chemical is added to reach a specific dilution in the water column. An alternative is to calculate the entire volume and then treat only one-fourth or one-third of the total water column, based on surface area, confining the treatment to selected sections of the pond where the pest infestation may be more intense. Specific application techniques include injection directly into the water with undiluted chemical, or some dilution of the chemical sprayed or cast upon the surface of the water. With either method, further dispersal throughout the water column is dependent upon water currents.

3. **Bottom acre-foot treatments**
This is a specialized application technique which is intended primarily for control of submersed aquatic vegetation. A boat carrying application equipment drags a hose or boom over and just above the pond bottom. The chemical is dispersed through nozzles, and the specific gravity of the chemical causes the treatment to remain near the bottom and in proximity of the rooted submersed weeds.

Specialized Treatments

Generally, the treatment methods described below require either the fish to be removed from the culture area being treated and then returned, or instead of treating the culture water to remove a pest, the fish themselves are treated with a chemical, usually incorporated into their feed.

1. **Dip Method**
This involves exposure of the fish to a strong solution of chemical for a short period of time. Fish are usually netted and dipped into a chemical and returned to the culture area.

2. **Flush Method**
This method is only applicable in tanks, raceways, or egg incubators. A stock solution of a chemical is applied in the upper end of the unit and allowed to flush throughout the system. The chemical must flush through the system in a predetermined time.

3. **Bath Treatments**
Bath treatments involve application of a chemical directly to the culture area and after a specified time, flushing it from the rearing unit. Bath treatments may be commonly used in culture tanks but are difficult to apply in ponds because most managers do not have an adequate water supply to flush the pond after treatment.

4. **Feeding Method**
Feeding involves the incorporation of a drug or medication in a feed, or in some other way introduces the chemical into the stomach of the fish. This treatment is the most common method used in treating bacterial infections and internal parasites of fish.

5. **Injection Method**
Some medications and drugs can be injected into fish for effective control of a disease. It is generally not practical in pond or intensive culture systems unless the fish have a high economic value.

Conversions

Table 3. Conversions for Units of Volume

From \ To	CM^3	liter	M^3	IN^3	ft^3	fl.oz.	fl. pt.	fl.qt.	gal.
CM^3	1	0.001	$1x10^{-6}$	0.0610	$3.53x10^{-5}$	0.0338	0.00211	0.00106	$2.64x10^{-4}$
liter	1000	1	0.001	60.98	0.353	33.81	2.113	1.057	0.2642
M^3	$1x10^6$	1000	1	$6.1x10^4$	35.31	$3.38x10^4$	2113	1057	264.2
IN^3	16.39	0.0164	$1.64x10^{-5}$	1	$5.79x10^{-4}$	0.5541	0.0346	0.0173	0.0043
ft^3	$2.83x10^4$	28.32	0.0283	1728	1	957.5	59.84	29.92	7.481
fl. oz.	29.57	0.0296	$2.96 x 10^{-5}$	1.805	0.00104	1	0.0625	0.0313	0.0078
fl. pt.	473.2	0.4732	$4.73x10^{-4}$	28.88	0.0167	16	1	0.5	0.125
fl.qt.	946.2	0.9463	$9.46x10^{-4}$	57.75	0.0334	32	2	1	0.25
gal.	3785	3.785	0.0038	231.0	0.1337	128	8	4	1

Table 4. Conversions for Units of Length

From \ To	cm	m	in.	ft.	yd
cm	1	0.01	0.3937	0.0328	0.0109
m	100	1	39.37	3.281	1.0936
in.	2.54	0.0254	1	0.0833	0.0278
ft.	30.48	0.3048	12	1	0.3333
yd.	91.44	0.9144	36	3	1

Table 5. Conversion for Units of Weight

From \ To	g	kg	gr.	oz.	lb.
g	1	0.001	15.43	0.0353	0.0022
kg	1000	1	$1.54 x 10^5$	35.27	2.205
gr.	0.0648	$6.48 x 10^5$	1	0.0023	$1.43 x 10^{-4}$
oz.	28.35	0.0284	437.5	1	0.0625
lb.	453 6	0.4536	7000	6	1

Table 6. Miscellaneous Conversion Factors

1 acre-foot	43,560	cubic feet
1 acre-foot	325,580	gallons
1 acre-foot of water	2,718,144	pounds
1 cubic-foot of water	62.4	pounds
1 gallon of water	8.34	pounds
1 gallon of water	3,785	grams
1 liter of water	1,000	grams
1 fluid ounce	29.57	grams

Helpful Formulas for Determining Volume

1. Volume of a square or rectangle container = length x width x depth
2. Volume of a circular container = 3.14 x radius^2 x depth
3. Volume of a pond = surface acres x average depth = acre-feet

Abbreviations

cm	=	centimeter
cm^3	=	cubic centimeter
fl oz	=	fluid ounce
fl pt	=	fluid pint
fl qt	=	fluid quart
ft	=	foot
ft^3	=	cubic foot
gal	=	gallon
g	=	gram
gr	=	grain
in	=	inch
in^3	=	cubic inch
kg	=	kilogram
lb	=	pound
m	=	meter
m^3	=	cubic meter
oz	=	ounce
yd	=	yard

Attention! Pesticide Precautions

1. Observe all directions, restrictions and precautions on pesticide labels. It is dangerous, wasteful, and illegal to do otherwise.
2. Store all pesticides in original containers with labels intact and behind locked doors. KEEP PESTICIDES OUT OF THE REACH OF CHILDREN.
3. Use pesticides at correct label dosages and intervals to avoid illegal residues or injury to plants and animals.
4. Apply pesticides carefully to avoid drift or contamination of non-target areas.
5. Surplus pesticides and containers should be disposed of in accordance with label instructions so contamination of water and other hazards will not result.
6. Follow directions on the pesticide label regarding restrictions as required by state and federal laws and regulations.
7. Avoid any action that may threaten an endangered species or its habitat. Your county extension agent can inform you of endangered species in your area, help you identify them and through the Fish and Wildlife Service Field Office, identify actions that may threaten endangered species or their habitats.

This course contains EPA's federal snd State rule requirements. Please be aware that each state implements drinking water and/or pesticide regulations that may be more stringent than EPA's or State regulations. Check with your state environmental agency for more information.

Grass Carp for Weed Control Section

Aquatic weeds are a serious problem for pond owners throughout the U.S. They restrict access to fishing areas, reduce fish harvest and decrease the usefulness, attractiveness and value of a pond. Herbicides, mechanical removal, water level changes, dyes, fertilization, proper pond construction, pond renovation and biological methods successfully control unwanted aquatic weed growth. The physical and chemical characteristics of the pond and the pond owner's objectives dictate which method is most appropriate. Pond owners are familiar with the traditional methods of aquatic weed control but not with the recently available option of biological control by using sterile triploid grass carp (Figure 1).

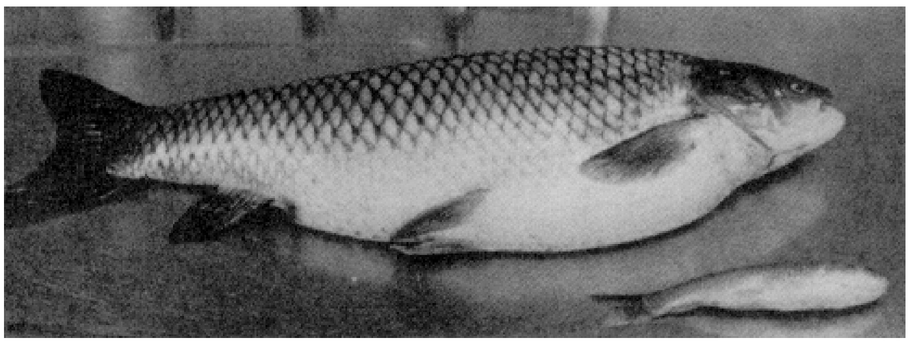


Figure 1. Nine-inch triploid grass carp stocked in a central Georgia pond with a heavy weed infestation grew to lengths of 29 inches and weights of almost 20 pounds in 16 months.

The grass carp (*Cteno pharyngodon idella*) occurs naturally in large rivers of the eastern USSR and China. It was introduced into the United States in 1963 by the United States Bureau of Sport Fisheries and Wildlife in cooperation with Auburn University. The feeding habits of the grass carp were well known and it was thought to have great potential as a biological weed control agent.

However, there was concern that the grass carp could reproduce in the wild and become an environmental nuisance, destroying valuable areas such as wetlands, swamps and waterfowl feeding grounds.

Because of these environmental concerns, early research focused on developing sterile populations. Attempts included producing single-gender populations, creating sterile hybrids and removing gonads. Success was limited because these methods were seldom 100% effective and verification of sterility was difficult. In the early 1980s researchers and commercial producers began treating eggs with heat, cold, or pressure to inhibit the second maturation division in the fertilized egg. This produced fish with abnormal chromosome numbers.

The normal diploid grass carp has a chromosome number (2N) of 48, while the triploid grass carp has a chromosome number (3N) of 72. The extra chromosomes result in sterility. Unfortunately, not all treated eggs develop into fish with abnormal chromosome numbers. A technique using an electronic particle size analyzer was developed in the early 1980s which identifies carp as triploids or diploids.

Feeding Habits

Triploid and diploid grass carp appear to consume similar quantities of aquatic plants and to have similar feeding habits, preferring succulent young plants. Table 1 lists some common aquatic plants and rates them by grass carp feeding preferences. Grass carp will not control all types of aquatic weeds. Because of selective feeding habits, they can eliminate one plant species and make room for the expansion of others.

Table 1. Feeding preferences of grass carp on some common aquatic plants.

High	Moderate	Low
Musk-grass	Duckweeds	Eel grass
Naiads	Pondweeds	Watermeal
Hydrilla	Bladderwort	Cattail
American elodea	Fanwort	Milfoil
	Water pennywort	Parrot feather
	Coontail	Reeds
	Water primrose	Sedges
	Filamentous algae	Water hyacinth
		Alligator weed
		Spatterdock
		Yellow cowlily
		Maidencane
		Torpedo grass
		Watershield Waterlily

Stocking

If the grass carp is the preferred weed control option, stocking proper numbers is important. Stocking rates of five to over 200 fish per acre have been used depending on plant species, plant density and distribution, the size and age of the fish and the pond owner's objectives. There are computer models that determine the appropriate stocking density by considering additional factors such as the amount of human activity around the pond, the desired level of control, and grass carp feeding preferences. The numbers recommended are designed to provide a 75 to 90 percent reduction in target plant species in three to four years. In most situations complete removal of aquatic vegetation is undesirable because the vegetation provides cover for small fish and attachment surfaces for fish food organisms.

Grass carp stocking densities are based on the maximum expected weed coverage and the feeding preference rating of the weeds. Stock 10, 15, or 20 fish per acre depending on whether the target weed species is high, moderate or low on the feeding preference list, respectively. This stocking concept is best illustrated using a few examples:

Example 1: A 10 acre pond is examined in March and found to have five acres of naiads growing in it. However, three of the remaining five acres are shallow and the naiads are expected to spread to this area later in the growing season. Base the stocking rate on the maximum expected weed coverage (eight acres). Because naiads are high on the feeding preference list, stock a total of 80 fish (eight acres times 10 fish per acre).

Example 2: A 10 acre pond is examined in March and found to have five acres covered in watermeal. Because watermeal is a floating plant, pond depth does not matter. The maximum expected weed coverage would be the entire 10 acres. Stock two hundred fish (10 acres times 20 fish per acre).

Example 3: A 10 acre pond is examined in March and found to have a one acre infestation of water primrose. Because water primrose grows only in shallow water (less than two feet deep), base the stocking rate on the area of the pond less than two feet deep. If two acres of the pond are less than two feet deep, stock 30 fish (two acres times 15 fish per acre).

Grass carp could be stocked in weed-free ponds at low rates (five fish per acre) to prevent weeds from becoming established. However, the effectiveness of preventive stocking has not been determined.

Generally, no fewer than 10 fish should ever be stocked, regardless of the pond size, because the loss of even a few fish could result in ineffective weed control.

The number of fish and the time required to achieve weed control can be reduced by using grass carp with other aquatic weed control options. For example, herbicides or mechanical removal can be used prior to fish introductions. If the established aquatic vegetation is removed, the tender new growth can be controlled by fewer fish.

Time of stocking affects the initial degree of weed control. Fish are cold-blooded animals whose feeding rates and metabolism are influenced by water temperature. Grass carp feeding is greatest when the water temperature is between 70 and 80°F and negligible when it is less than 50°F. Mortality associated with handling stress is less likely when the water temperature is cooler; therefore, fish stocked in late winter or early spring are more likely to survive. They will not begin feeding heavily until late spring or early summer, which is when most aquatic weeds begin growing.

Because grass carp are attracted to currents, ponds with water flowing over spillways or through drains are not suitable without renovation. Cover horizontal drains with a fence or bars that allow free flow of water but prevent passage of grass carp. If barriers are placed over any drain structures, make sure they do not become clogged or blocked. Water could flow over emergency spillways and possibly wash out the spillway or dam.

Predatory Fish

Predatory fish, such as largemouth bass, eat grass carp. If used with existing fish populations, grass carp should be large enough to avoid being eaten by the average size predator. A largemouth bass 12 to 14 inches long can swallow a grass carp approximately nine inches long. Even if predation is not a problem, the pond owner should consider using larger carp if they are available because they tend to survive handling and stocking better. Grass carp stocked with existing fish populations should be at least 8-10 inches in length.

Grass carp do not reproduce in ponds and periodic restocking is required. It has been reported that the lifespan of the grass carp is between 10 and 15 years; however, triploid grass carp will provide effective vegetation control for 8-10 years.

Grass carp grow rapidly in ponds that have preferred plant species. Nine to 11 inch fish stocked in the early spring can reach lengths of 25 inches or more and weights of seven to 10 pounds by the end of the first year.

If appropriate numbers of grass carp are stocked, they will eventually reduce the vegetation to the point that new plant growth is eaten as it becomes available. The grass carp will survive and remain healthy but will not increase in size. Once stocked, grass carp are difficult to remove from a pond. They are almost impossible to remove by seining or angling. The only options are draining the pond or using toxicants such as rotenone.

Permit Requirements
Only certain producers are authorized to sell grass carp in most States because they must confirm that each fish is a triploid. Most State agencies periodically examine shipments of grass carp to verify triploidy. If diploid fish are found, the person possessing or selling the fish is subject to serious legal action, including large fines and imprisonment, as well as having the stock destroyed.
Depending upon your State Agency, the pond owner must meet the following criteria to have Grass Carp:

1. Sterile triploid grass carp are purchased from sources authorized by State Agency. A list of currently approved dealers is available from your Game and Fish or Pesticide Agencies.
2. The pond owner retains the bill of sale as proof of legal purchase.
3. The pond is privately owned, that is, a body of water which is clearly and entirely within the title of one owner.
4. Fish cannot travel upstream or downstream directly into a body of water not owned by the pond owner.

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Common Carp

Cyprinus carpio

Family: Cyprinidae (Minnows or carps)

Order: Cypriniformes (carps)

Class: Actinopterygii (ray-finned fishes)

Max. size: 120 cm SL (male/unsexed; Ref. 2847); max. published weight: 37.3 kg (Ref. 40637); max. reported age: 47 years

Environment: benthopelagic; non-migratory; freshwater; brackish; pH range: 7.0 - 7.5; dH range: 10.0 - 15.0.

Climate: temperate; 3 - 32°C; 60°N - 40°N

Global Importance: fisheries: highly commercial; aquaculture: commercial; gamefish: yes; aquarium: public aquariums.

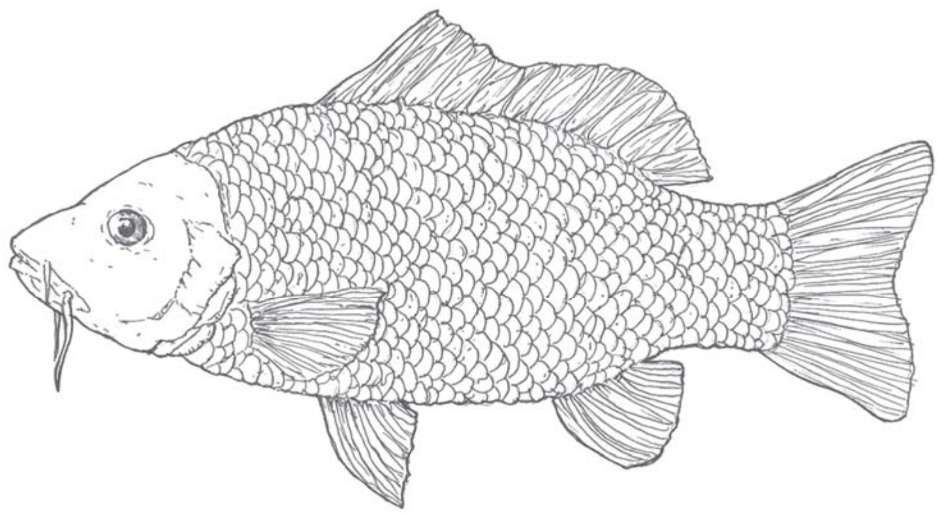
Resilience: Low, minimum population doubling time 4.5 - 14 years (K=0.11-0.17; tm=1-5; tmax=47; Fec=36,000-2,000,000)

Distribution: Western Europe throughout Eurasia to China, and South-East Asia, Siberia and India. One of the first species to be introduced into other countries and now attains global distribution. Inland aquaculture and capture fisheries contributions proved to be very significant. A reophilic wild population in the Danube is assumed to be the origin of the European species; this population is now under threat (Ref. 13696).

Several countries report adverse ecological impact after introduction.

Diagnosis: Dorsal spines (total): 3-4; Dorsal soft rays (total): 17-23; Anal spines: 2-3; Anal soft rays: 5-6; Vertebrae: 36-37. Pharyngeal teeth 1, 1, 3:3, 1,1, robust, molar-like with crown flattened or somewhat furrowed. Scales large and thick.

`Wild carp ' is generally distinguished by it's less stocky build with height of body 1:3.2-4.8 in standard length. Very variable in form, proportions, squamation, development of fins, and color. Caudal fin with 3 spines and 17-19 rays (Ref. 2196). Last simple anal ray bony and serrated posteriorly; 4 barbels; 17-20 branched dorsal rays; body grey to bronze (Ref. 43281). Also Ref. 3398, 3410.



CARP ***(Carpio cyprinus)***

Biology: Occur at a temperature range of 3-35°C. Hardy and tolerant of a wide variety of conditions but generally favor large water bodies with slow flowing or standing water and soft bottom sediments.

Common carp thrive in large turbid rivers. They are omnivorous, feeding mainly on aquatic insects, crustaceans, annelids, mollusks, weed and tree seeds, wild rice, aquatic plants and algae; mainly by grubbing in sediments (Ref. 1998). Spawn in spring and summer, laying sticky eggs in shallow vegetation (Ref. 7248). A female 47 cm in length produces about 300,000 eggs (Ref. 6885).

Young are probably preyed upon by northern pike, muskellunge, and largemouth bass. Adults uproot and destroy submerged aquatic vegetation and therefore may be detrimental to duck and native fish populations (Ref. 1998). Utilized fresh and frozen (Ref. 9987)

Non-Native Commonly Found Plants Section

Common Name	Scientific Name	Habitats Invaded
Trees:		
Amur Maple	*Acer ginnala**	prairie, disturbed
Norway Maple	*Acer platanoides**	forest
Tree-of-Heaven	*Ailanthus altissima*	disturbed, forest
European (Black) Alder	*Alnus glutinosa*	wetland, forest
Russian Olive	*Elaeagnus angustifolia**	prairie
Autumn Olive	*Elaeagnus umbellata**	prairie, forest
White Mulberry	*Morus alba**	disturbed
Scotch Pine	*Pinus sylvestris**	prairie, disturbed
White Poplar	*Populus alba**	forest, prairie
Buckthorns:Common	*Rhamnus cathartica**	forest, prairie, disturbed
Glossy	*Rhamnus frangula* *	forest, wetland
European Mountain Ash	*Sorbus acuparia*	forest
Chinese Elm	*Ulmus parviflora**	prairie, forest
Siberian Elm	*Ulmus pumila* *	prairie, forest
Shrubs:		
Japanese Barberry	*Berberis thunbergii* *	forest
European Barberry	*Berberis vulgaris* *	forest
Siberian Pea Shrub	*Caragana arborescens**	forest
Burning Bush	*Euonymus alatus* *	forest
Common Privet	*Ligustrum vulgare* *	forest, savanna, prairie
Amur Honeysuckle	*Lonicera maacki*	forest, savanna, prairie
Honeysuckles:Tartarian	*Lonicera morrowii**	forest, savanna, prairie
Morrow's	*Lonicera tatarica**	forest, savanna, prairie
Bella	*Lonicera x bella*	forest, savanna, prairie
Black jet-bead	*Rhodotypos scandens**	forest
Multiflora Rose	*Rosa multiflora*	forest, prairie
Wayfaring Tree	*Viburum lantana**	forest
European Highbush Cranberry	*Viburnum opulus* *	forest
Vines:		
Porcelain Berry	*Ampelopsis brevipedunculata* *	forest
Round-leaved Bittersweet	*Celastrus orbiculatus**	forest, savanna, prairie
Field Bindweed	*Convolvulus arvensis*	disturbed, prairie
Wintercreeper	*Euonymous fortunei* *	forest
English Ivy	*Hedera helix* *	forest
Everlasting pea	*Lathyrus latifolia**	disturbed
Japanese Honeysuckle	*Lonicera japonica**	forest
Mile-a-minute	*Polygonum perfoliatum*	forest
Deadly Nightshade	*Solanum dulcamara*	disturbed, wetland, forest
Periwinkle	*Vinca minor* *	forest, savanna
Black Swallow-wort	*Vincetoxicum nigrum*	forest, savanna, prairie
Dog-strangling Vine	*Vincetoxicum rossicum*	forest, savanna
Forbs:		
Bishop's Goutweed	*Aegopodium podagraria**	prairie, forest
Garlic Mustard	*Alliaria petiolata*	forest, savanna

Common Burdock	*Arctium minus*	disturbed, forest
Creeping bellflower	*Campanula rapunculoides**	disturbed
Thistles:Plumeless	*Carduus acanthoides*	prairie, disturbed
Musk	*Carduus nutans*	prairie, disturbed
Spotted Knapweed	*Centaurea biebersteinii*	disturbed, prairie, dune
Russian knapweed	*Centaurea repens*	disturbed, prairie, dune
Celandine	*Chelidonium majus**	forest
Ox-eye daisy	*Chrysanthemum*	prairie
Chicory	*leucanthemum**	disturbed, prairie
Thistles:Canada	*Cichorium intybus**	prairie, disturbed
Bull	*Cirsium arvense*	prairie, disturbed
Poison hemlock	*Cirsium vulgare*	wetland
Lily-of-the-Valley	*Conium maculatum*	forest
Crown Vetch	*Convallaria majalis**	prairie
Queen Anne's Lace	*Coronilla varia* *	prairie, disturbed
Grecian foxglove	*Daucus carota**	grasslands, woodlands
Teasels:Cut-Leaved	*Digitalis lanata*	prairie, wetland
Common	*Dipsacus laciniatus* *	prairie, wetland
Hairy Willow Herb	*Dipsacus sylvestris* *	wet prairie
Helleborine	*Epilobium hirsutum*	forest
Cypress Spurge	*Epipactis helleborine*	prairie
Leafy Spurge	*Euphorbia cyparrissias**	prairie, disturbed
Queen-of-the-Meadow	*Euphorbia esula*	wet prairie
Creeping Charlie	*Filipendula ulmaria*	disturbed, forest
Baby's Breath	*Glechoma hederacea*	dune
Orange Day Lily	*Gypsophila paniculata**	disturbed, prairie
Dame's Rocket	*Hemerocallis fulva**	forest, prairie
Orange Hawkweed	*Hesperis matronalis* *	prairie
Yellow Hawkweed	*Hieracium aurantiacum*	prairie
Common St. John's-Wort	*Hieracium canadense*	prairie, dune
Nipplewort	*Hypericum perforatum**	forest, disturbed
Silky Bush Clover	*Lapsana communis*	prairie
Butter-and-Eggs	*Lespedeza cuneata*	disturbed, prairie
Bird's foot Trefoil	*Linaria vulgaris*	prairie
Moneywort	*Lotus corniculatus**	wetland
Purple Loosestrife	*Lysimachia nummularia**	wetland
Sweet Clovers:White	*Lythrum salicaria*	prairie
Yellow	*Melilotus alba* *	prairie
Garden Forget-me-not	*Melilotus officinalis* *	forest
Star-of-Bethlehem	*Myosotis sylvatica**	forest, disturbed
Wild Parsnip	*Ornithogalum umbellatum*	prairie, disturbed
Japanese Knotweed	*Pastinaca sativa* *	forest, savanna, disturbed
Giant Knotweed	*Polygonum cuspidatum**	disturbed
Lesser Celandine	*Polygonum sacchilense*	forest
Field Sorrel	*Ranunculus ficaria**	disturbed, prairie
Curly Dock	*Rumex acetosella*	disturbed, prairie
Bouncing Bet	*Rumex crispus*	disturbed, prairie
Bladder-Campion	*Saponaria officinalis*	disturbed
Common Tansy	*Silene vulgaris*	disturbed, prairie
Field Hedge Parsley	*Tanacetum vulgare**	forest
Japanese Hedge Parsley	*Torilis arvensis*	prairie, wetland
Red Clover	*Torilis japonica*	prairie
White Clover	*Trifolium pratense**	prairie
Garden Heliotrope	*Trifolium repens**	wetland
Common Mullein		disturbed, prairie

	*Valeriana officinalis** *Verbascum thaspus*	
Grasses and Grass-like Species: Smooth Brome Quack Grass Tall Fescue Japanese Stilt Grass Pampas Grass Reed Canary Grass Phragmites Bluegrasses:Canada Kentucky Johnson Grass Cattails: Narrow-leaved Hybrid	 *Bromus inermis** *Elytrigia repens** *Festuca arundinacea** *Microstegium vimineum* *Miscanthus sinensis** *Phalaris arundinacea* * *Phragmites australis* *Poa compressa* * *Poa pratensis* * *Sorghum halepense* *Typha angustifolia** *Typha* x *glauca*	 prairie prairie prairie forest disturbed, prairie wetlands, prairie, forest disturbed, wetland prairie prairie disturbed wetlands wetlands
Aquatics: Flowering Rush Yellow Water Flag Aquatic Forget-Me-Not Eurasian Water Milfoil Watercress Curly-Leaf Pondweed Water Chestnut	 *Butomus umbellatus** *Iris pseudacorus** *Myosotis scorpioides* *Myriophyllum spicatum* *Nasturtium officinale** *Potamogeton crispus* *Trapa natans**	 aquatic, wetlands aquatic, wetlands aquatic aquatic aquatic aquatic aquatic

Green Taro (Colocasia esculenta)

Commonly found in wastewater effluent ponds because of the plant's ability to uptake or remove toxic materials. Taro, a popular ethnic food, can be found as 'taro chips', but more commonly the starchy root is cooked or steamed. There is a purple leaf variety grown ornamentally for its spectacular large leaves, which can grow huge in tropical climates or over the summer in rich soil. Dig up the large bulb before frost and store like other bulbs in vermiculate over the winter.

Pigroot

Aquatic Plant Taxonomy Section

BRYOPHYTA
RICCIACEAE
Riccia fluitans L. **Slender Riccia**
Ricciocarpus natans (L.) Corda **Purple-fringed Riccia**

LYCOPODIOPHYTA
ISOËTACEAE
Isoëtes spp. **Quillwort**

EQUISETOPHYTA
EQUISETACEAE
Equisetum arvense L. **Field Horsetail**

POLYPODIOPHYTA
DRYOPTERIDACEAE
Onoclea sensibilis L. **Sensitive Fern**
MARSILEACEAE
Marsilea quadrifolia L. **Pepperwort**
OSMUNDACEAE
Osmunda cinnamomea L. **Cinnamon Fern**
Osmunda claytoniana L. **Interrupted Fern**
Osmunda regalis L. var. *spectabilis* (Willd.) Gray **Royal Fern**
THELYPTERIDACEAE
Thelypteris palustris Schott var. *pubescens* (Lawson) Fernald **Marsh Fern**

PINOPHYTA
PINACEAE
Larix laricina (DuRoi) K. Koch **Larch; Tamarack**
Picea mariana (Mill.) BSP. **Black Spruce**
TAXODIACEAE
Taxodium distichum (L.) Rich. **Bald Cypress**

MAGNOLIOPHYTA - DICOTYLEDONS
ACERACEAE
Acer rubrum L. **Red Maple**
AIZOACEAE
Mollugo verticillata L. **Carpetweed**
AMARANTHACEAE
Amaranthus cannabinus (L.) J. D. Sauer **Saltmarsh Hemp; Waterhemp**
Amaranthus tuberculatus (Moq.) Sauer **Water Hemp**
ANACARDIACEAE
Toxicodendron radicans (L.) Ktze. **Poison Ivy**
Toxicodendron vernix (L.) Ktze. **Poison Sumac**
APIACEAE (= UMBELLIFERAE)
Cicuta bulbifera L. **Water Hemlock**
Cicuta maculata L. **Water Hemlock; Cowbane**
Hydrocotyle americana L. **Marsh Pennywort**
Lilaeopsis chinensis (L.) Ktze. **Lilaeopsis**
Ptilimnium capillaceum (Michx.) Raf. **Mock Bishop's Weed**
Sium suave Walt. **Water Parsnip**
AQUIFOLIACEAE
Ilex verticillata (L.) Gray **Winterberry**

ASCLEPIADACEAE
Asclepias incarnata L. **Swamp Milkweed**
ASTERACEAE (= COMPOSITAE)
Aster lateriflorus (L.) Britt. **Calico Aster**
Aster nemoralis Ait. **Bog Aster**
Aster novi-belgii L. **New York Aster**
Aster puniceus L. **Purple-stemmed Aster**
Aster simplex Willd. **Marsh Aster**
Aster tenuifolius L. **Saltmarsh Aster**
Baccharis halimifolia L. **Groundsel Tree; Sea Myrtle**
Bidens cernua L. **Nodding Beggar's Ticks; Sticktight**
Bidens comosa (Gray) Wieg. **Leafy Bracted Tickseed**
Bidens connata Muhl. ex Willd. **Swamp Beggar's Ticks**
Bidens coronata (L.) Britt. **Tall Tickseed-Sunflower**
Bidens frondosa L. **Common Beggar's Ticks**
Bidens vulgata Greene **Tall Beggar's Ticks**
Bidens vulgata Greene forma *puberula* (Wiegand) Fern. **Tall Beggar's-ticks**
Cirsium muticum Michx. **Swamp Thistle**
Eupatorium dubium Willd. **Joe-Pye-Weed**
Eupatorium perfoliatum L. **Boneset**
Helenium autumnale L. **Sneezeweed**
Iva frutescens L. **Marsh Elder; Gall Bush**
Megalodonta beckii (Torr.) Greene **Water Marigold**
Mikania scandens (L.) Willd. **Climbing Hempweed**
Pluchea purpurascens (Swartz) DC. **Saltmarsh Fleabane; Camphorweed**
Sclerolepis uniflora (Walt.) BSP. **Sclerolepis**
Solidago graminifolia (L.) Salisb. **Goldenrod**
Solidago sempervirens L. **Seaside Goldenrod**
Xanthium strumarium L. **Cocklebur**
BALSAMINACEAE
Impatiens capensis Meerb. **Jewelweed; Spotted Touch-me-not; Upside-down Mouse Plant**
BETULACEAE
Alnus rugosa (DuRoi) Spreng. **Speckled Alder**
BORAGINACEAE
Myosotis scorpioides L. **Forget-me-not**
BRASSICACEAE (= CRUCIFERAE)
Cardamine pensylvanica Muhl. **Bitter Cress**
Nasturtium officinale R. Br. **Watercress**
Neobeckia aquatica (Eaton) Green **Lake Cress**
Rorippa amphibia (L.) Bess. **Yellow Cress**
Rorippa palustris (L.) Bess. **Yellow Cress**
Rorippa sylvestris (L.) Bess. **Creeping Yellow Cress**
CABOMBACEAE
Brasenia schreberi Gmelin **Water Shield**
Cabomba caroliniana Gray **Fanwort**
CALLITRICHACEAE
Callitriche heterophylla Pursh var. *heterophylla* **Water Starwort**
Callitriche terrestris Raf. **Water Starwort**
Callitriche verna L. **Water Starwort**
CAMPANULACEAE
Campanula aparinoides Pursh **Marsh Bellflower**
Lobelia cardinalis L. **Cardinal Flower**
Lobelia dortmanna L. **Water Lobelia**
Lobelia inflata L. **Lobelia**
Lobelia kalmii L. **Brook Lobelia**
Lobelia siphilitica L. **Great Blue Lobelia**

CAPRIFOLIACEAE
Sambucus canadensis L. **Common Elderberry**
CARYOPHYLLACEAE
Sabatia stellaris Pursh **Marsh Pink; Sea Pink**
Spergularia marina (L.) Griseb. **Saltmarsh Sand-Spurrey**
CERATOPHYLLACEAE
Ceratophyllum demersum L. **Hornwort**
Ceratophyllum echinatum A. Gray **Hornwort**
CHENOPODIACEAE
Atriplex arenaria Nuttall **Seabeach Orach**
Atriplex patula L. **Orach; Spearscale**
Salicornia europaea L. **Saltwort; Glasswort; Samphire**
Salicornia bigelovii Torr. **Dwarf Saltwort**
Salicornia virginica L. **Woody Glasswort**
Suaeda linearis (Ell.) Moq. **Tall Sea Blite**
Suaeda maritima (L.) Dumort. **Low Sea Blite**
CLETHRACEAE
Clethra alnifolia L. **White Alder; Sweet Pepperbush**
CORNACEAE
Cornus amomum Mill. **Silky Dogwood**
Cornus stolonifera Michx. **Red Osier Dogwood**
CUSCUTACEAE
Cuscuta sp. **Dodder**
DROSERACEAE
Drosera intermedia Hayne **Spatulate-leaved Sundew**
Drosera rotundifolia L. **Round-leaved Sundew**
ELATINACEAE
Elatine minima (Nutt.) Fisch. & Mey. **Mud Purslane**
ERICACEAE
Chamaedaphne calyculata (L.) Moench **Leather-leaf**
Kalmia angustifolia L. **Sheep-laurel (Baaa-g laurel)**
Kalmia polifolia Wang. **Bog-laurel**
Ledum groenlandicum Oeder **Labrador-tea**
Lyonia ligustrina (L.) DC. **Maleberry**
Rhododendron canadense (L.) Torr. **Rhodora**
Rhododendron viscosum (L.) Torr. **Swamp Azalea**
Vaccinium corymbosum L. **Highbush Blueberry**
Vaccinium macrocarpon Ait. **Large Cranberry**
Vaccinium oxycoccus L. **Small Cranberry**
GENTIANACEAE
Gentiana andrewsii Griseb. **Closed Gentian**
Menyanthes trifoliata L. **Bog Buckbean**
Nymphoides cordata (Ell.) Fern. **Floating-heart**
HALORAGACEAE
Myriophyllum alterniflorum DC. **Slender Water-milfoil**
Myriophyllum aquaticum (Vellozo) Verdcourt **Parrot's Feather**
Myriophyllum exalbescens Fern. **American Water-milfoil**
Myriophyllum farwellii Morong **Farwell's Water-milfoil**
Myriophyllum heterophyllum Michx. **Variable-leaved Water -milfoil**
Myriophyllum humile (Raf.) Morong **Low Water-milfoil**
Myriophyllum pinnatum (Walt.) BSP. **Pinnate Water-milfoil**
Myriophyllum spicatum L. **Eurasian Water-milfoil**
Myriophyllum tenellum Bigel. **Leafless Water-milfoil**
Myriophyllum verticillatum L. **Green Milfoil**
Proserpinaca palustris L. **Mermaid-weed**

HYPERICACEAE
Hypericum boreale (Britton) Bicknell **St. John's-wort**
Hypericum boreale (Britton) Bicknell forma *callitrichoides* Fassett **St. John's-wort**
Hypericum canadense L. **Narrow-leaved St. John's-wort**
Hypericum mutilum **St. John's-wort**
Triadenum fraseri (Spach) Gl. **Marsh St. John's-wort**
Triadenum virginicum (L.) Raf. **Marsh St. John's-wort**
LAMIACEAE (= LABIATAE)
Lycopus americanus Muhl. **Water Horehound**
Lycopus europaeus L. **European Water Horehound**
Lycopus rubellus Moench. **Gypsywort**
Lycopus uniflorus Michx. **Common Bugleweed**
Lycopus virginicus L. **Virginia Water-horehound; Bugleweed**
Mentha aquatica L. **Water Mint**
Mentha arvensis L. **Field Mint**
Mentha piperita L. **Peppermint**
Mentha spicata L. **Spearmint**
Pycnanthemum virginianum (L.) Durand & Jackson **Mountain Mint**
Scutellaria epilobiifolia A. Hamilt. **Marsh Skullcap**
Scutellaria lateriflora L. **Mad-dog Skullcap**
Stachys hyssopifolia Michx. **Hyssop Hedge-nettle**
Teucrium canadense L. **Seaside Germander**
LENTIBULARIACEAE
Utricularia geminiscapa Benj. **Bladderwort**
Utricularia gibba L. **Humped Bladderwort**
Utricularia intermedia Hayne **Flat-leaved Bladderwort**
Utricularia minor L. **Small Bladderwort**
Utricularia purpurea Walt. **Purple Bladderwort**
Utricularia radiata Small **Inflated Bladderwort**
Utricularia vulgaris L. **Common Bladderwort**
LYTHRACEAE
Decodon verticillatus (L.) Ell. **Swamp Loosestrife**
Lythrum lineare L. **Saltmarsh Loosestrife**
Lythrum salicaria L. **Purple Loosestrife**
Rotala ramosior (L.) Koehne. **Rotala**
MALVACEAE
Althea officinalis L. **Marsh Mallow**
Hibiscus palustris L. **Swamp Rose Mallow**
MYRICACEAE
Myrica gale L. **Sweet Gale**
Myrica pensylvanica Loisel. **Bayberry**
NELUMBONACEAE
Nelumbo lutea (Willd.) Pers. **American Water Lotus**
NYMPHAEACEAE
Nuphar advena (Ait.) Ait. f. **Large Yellow Pond-lily**
Nuphar microphylla (Pers.) Fern. **Small Yellow Pond-lily**
Nuphar × rubrodisca Morong **Red Cow-lily**
Nuphar variegata Durand **Bullhead Lily; Spatterdock**
Nymphaea odorata Aiton **Fragrant White Water Lily**
Nymphaea tuberosa Paine **Tuberous White Water Lily**
ONAGRACEAE
Epilobium glandulosum Lehm. var. *adenocaulon*(Haussk.) Fern. **Northern Willow-herb**
Ludwigia alternifolia L. **Seedbox**
Ludwigia palustris (L.) Ell. **False Loosestrife**
Ludwigia lacustris Eames **False Loosestrife**

PLANTAGINACEAE
Plantago maritima L. **Seaside Plantain**
PLUMBAGINACEAE
Limonium nashii Small **Sea-Lavender**
PODOSTEMACEAE
Podostemum ceratophyllum Michx. **Riverweed**
POLYGALACEAE
Polygala nuttallii Torrey & Gray **Nuttall's Milkwort**
Polygala sanguinea L. **Common Milkwort**
POLYGONACEAE
Polygonum amphibium L. **Water Smartweed**
Polygonum arifolium L. **Halberd-leaved Tear-thumb**
Polygonum caespitosum Blume. **Smartweed**
Polygonum coccineum Muhl. **Floating Water Smartweed**
Polygonum hydropiper L. **Water Pepper**
Polygonum hydropiperoides Michx. **Mild Water Pepper**
Polygonum lapathifolium L. **Nodding Smartweed**
Polygonum pensylvanicum L. **Pennsylvania Smartweed**
Polygonum persicaria L. **Lady's Thumb**
Polygonum punctatum Ell. **Water Smartweed**
Polygonum sagittatum L. **Arrow-leaved Tear-thumb**
Rumex crispus L. **Sour Dock**
Rumex maritimus L. **Golden Dock**
Rumex obtusifolius L. **Bitter Dock**
Rumex orbiculatus Gray **Great Water Dock**
Rumex verticillatus L. **Swamp Dock**
PRIMULACEAE
Hottonia inflata Ell. **Featherfoil**
Lysimachia ciliata L. **Fringed Loosestrife**
Lysimachia nummularia L. **Moneywort; Creeping Jenny**
Lysimachia terrestris (L.) BSP **Swamp-candles**
Lysimachia thyrsiflora L. **Tufted Loosestrife**
Samolus parviflorus Raf. **Water-pimpernal**
RANUNCULACEAE
Caltha palustris L. **Marsh-marigold**
Ranunculus longirostris Godr. **White Water Crowfoot**
Ranunculus flabellaris Raf. **Yellow Water Crowfoot**
Ranunculus sceleratus L. **Cursed Crowfoot**
Ranunculus septentrionalis Poir. **Swamp Buttercup**
Ranunculus subrigidus Drew **Stiff White Water Crowfoot**
Ranunculus trichophyllus Chaix **Common White Water Crowfoot**
ROSACEAE
Aronia melanocarpa (Michx.) Ell. **Black Chokeberry**
Potentilla fruticosa L. **Shrubby Cinquefoil**
Potentilla palustris (L.) Scop. **Marsh Cinquefoil**
Rosa palustris Marsh. **Swamp Rose**
Spiraea alba DuRoi **Meadow-sweet**
Spiraea tomentosa L. **Steeplebush**
RUBIACEAE
Cephalanthus occidentalis L. **Buttonbush**
Galium trifidum L. **Small Bedstraw**
SALICACEAE
Populus deltoides Marsh **Cottonwood**
Salix nigra Marsh **Black Willow**
SARRACENIACEAE
Sarracenia purpurea L. **Pitcher-plant**

SAURURACEAE
Saururus cernuus L. **Lizard's-tail**
SAXIFRAGACEAE
Chrysosplenium americanum Schwein. **Golden Saxifrage; Water Carpet**
Parnassia glauca Raf. **Grass-of-Parnassus**
Penthorum sedoides L. **Ditch Stonecrop**
SCROPHULARIACEAE
Agalinis maritima (Raf.) Raf. **Maritime Gerardia**
Agalinis purpurea (L.) Pennell **Purple Gerardia**
Chelone glabra L. **Turtlehead**
Glossostigma diandrum (L.) Kunze **Mud Mat**
Gratiola aurea Muhl. **Hedge Hyssop**
Gratiola aurea Pursh forma *pusilla* (Fassett) Pennell **Dwarf Hyssop**
Lindernia dubia (L.) Pennell **False Pimpernel**
Mimulus ringens L. **Square-stemmed Monkey Flower**
Pedicularis canadensis L. **Common Lousewort**
Pedicularis lanceolata Michx. **Swamp Lousewort**
Veronica americana (Raf.) Schwein. **American Brooklime**
Veronica beccabunga L. **European Brooklime**
SOLANACEAE
Solanum dulcamara L. **Bittersweet**
TRAPACEAE
Trapa natans L. **Water Chestnut**
URTICACEAE
Boehmeria cylindrica (L.) Sw. **False Nettle; Bog Hemp**
Pilea fontana (Lunell) Rydb. **Clearweed**
Pilea pumila (L.) Gray **Clearweed**
VERBENACEAE
Verbena hastata L. **Blue Vervain**
VIOLACEAE
Viola lanceolata L. **Lance-leaved Violet**

MAGNOLIOPHYTA - MONOCOTYLEDONS
ACORACEAE
Acorus americanus (Raf.) Raf. **Sweet Flag**
Acorus calamus L. **Sweet Flag**
ALISMATACEAE
Alisma plantago-aquatica L. var. *americanum* Schultes & Schultes (= *A. triviale* Pursh) **Water Plantain**
Alisma plantago-aquatica L. var. *parviflorum* (Pursh) Torrey (= *A. subcordatum* Raf.) **Water Plantain**
Echinodorus parvulus Engelmann **Burhead**
Sagittaria graminea Michx. **Narrow-leaved Arrowhead**
Sagittaria latifolia Willd. **Common Arrowhead; Duck Potato**
Sagittaria montevidensis Cham & Schlect. subsp. *spongiosus* (Engelm.) Bogin (= *Lophotocarpus calycinus*) **Arrowhead**
ARACEAE
Calla palustris L. **Wild Calla**
Orontium aquaticum L. **Golden Club**
Peltandra virginica (L.) Kunth **Arrow-Arum**
Pistia stratiotes L. **Water Lettuce**
Symplocarpus foetidus (L.) Nutt. **Skunk-cabbage**
CYPERACEAE
Bulbostylis capillaris (L.) C. B. Clarke **Bulbostylis**
Carex comosa Boott. **Sedge**

Carex crinita Lam. **Sedge**
Carex folliculata L. **Sedge**
Carex hystericina Willd. **Sedge**
Carex lacustris Willd. **Sedge**
Carex lasiocarpa Ehrh. **Sedge**
Carex lupulina Muhl. **Hop Sedge**
Carex lurida Wahlenb. **Sedge**
Carex scoparia Schkuhr **Sedge**
Carex projecta Mack. **Sedge**
Carex stricta Lam. **Tussock Sedge**
Carex trisperma Dew. **Sedge**
Carex vulpinoidea Michx. **Sedge**
Cladium mariscoides (Muhl.) Torr. **Twig Rush**
Cyperus aristatus Rottb. **Umbrella-sedge**
Cyperus dentatus Torrey **Nut Grass**
Cyperus diandrus Torr. **Umbrella-sedge**
Cyperus erythrorhizos Muhl. **Umbrella-sedge**
Cyperus esculentus L. **Yellow Nut-grass**
Cyperus ferruginescens Boeckl. **Rusty Cyperus**
Cyperus filiculmis Vahl. **Umbrella-sedge**
Cyperus rivularis Kunth **Umbrella-sedge**
Cyperus strigosus L. **Umbrella-sedge**
Dulichium arundinaceum (L.) Britt. **Three-way Sedge**
Eleocharis acicularis (L.) R. & S. **Needle Rush**
Eleocharis elliptica Kunth **Spike-rush**
Eleocharis erythropoda Steud. **Red-footed Spike-rush**
Eleocharis obtusa (Willd.) Schultes **Spike-rush**
Eleocharis olivacea Torr. **Spike-rush**
Eleocharis palustris (L.) R. & S. **Spike-rush**
Eleocharis parvula (R. & S.) Link **Dwarf Spike-rush**
Eleocharis robbinsii Oakes **Spike-rush**
Eriophorum virginicum L. **Tawny Cotton-grass**
Fimbristylis autumnalis (L.) R. & S. **Fimbristylis**
Hemicarpha micrantha (Vahl) Pax. **Hemicarpha**
Rhynchospora capitellata (Michx.) Vahl. **Beak-rush**
Rhynchospora alba (L.) Vahl. **Beak-rush**
Schoenoplectus purshianus (Fern.) Strong **Pursh's Bulrush**
Scirpus americanus Persoon (= *S. olneyi* Gray) **Three-square**
Scirpus atrovirens Willd. **Dark-green Bulrush**
Scirpus cyperinus (L.) Kunth var. *pedicellatus* (Fern.) Schuyler **Wool-grass**
Scirpus expansus Fern. **Bulrush**
Scirpus fluviatilis (Torrey) Gray **River Bulrush**
Scirpus pungens Vahl. **Three-square; Chairmaker's Rush**
Scirpus robustus Pursh **Saltmarsh Bulrush**
Scirpus smithii Gray **Bulrush**
Scirpus subterminalis Torrey **Water Bulrush**
Scirpus torreyi Olney **Bulrush**
Scirpus validus Vahl **Softstem Bulrush**

ERIOCAULACEAE

Eriocaulon aquaticum (Hill) Druce (= *E. septangulare* With.) **White Buttons; Pipewort**

HYDROCHARITACEAE

Egeria densa Planch. **Waterweed**
Elodea canadensis Michx. **Waterweed; Ditch Moss**
Elodea nuttallii (Planch.) St. John **Waterweed**
Hydrilla verticillata (L.f.) Royle **Hydrilla**

Limnobium spongia (Bosc.) Steud. **Frog's Bit**
Vallisneria americana Michx. **Wild Celery; Tapegrass**
IRIDACEAE
Iris pseudacorus L. **Yellow Iris**
Iris versicolor L. **Blue Flag**
JUNCACEAE
Juncus acuminatus Michx. **Rush**
Juncus articulatus L. **Rush**
Juncus brevicaudatus (Engelm.) Fern. **Rush**
Juncus canadensis J. Gay **Marsh Rush**
Juncus effusus L. **Soft Rush**
Juncus gerardi Loisel. **Black Rush**
Juncus marginatus Rostk. **Rush**
Juncus militaris Bigel. **BayonetRush**
Juncus nodosus L. **Rush**
Juncus pelocarpus Mey. **Rush**
Juncus tenuis Willd. **Path Rush**
JUNCAGINACEAE
Triglochin maritimum L. **Arrow-grass**
LEMNACEAE
Landoltia punctata (G.F.W. Meyer) Les & Crawford **Spotted Duckweed**
Lemna minor L. **Lesser Duckweed**
Lemna trisulca L. **Star Duckweed**
Lemna valdiviana Phil. **Duckweed**
Spirodela polyrhiza (L.) Schleid. **Greater Duckweed; Duck-meat**
Wolffia borealis (Engelm.) Landolt **Water-meal**
Wolffia brasiliensis Weddell **Water-meal**
Wolffia columbiana Karst. **Water-meal**
LIMNOCHARITACEAE
Hydrocleys nymphoides (Willdenow) Buchenau **Water Poppy**
NAJADACEAE
Najas flexilis (Willd.) Rostk. & Schmidt **Slender Naiad**
Najas gracillima (A. Br.) Magnus **Naiad**
Najas guadalupensis (Spreng.) Magnus **Southern Naiad**
Najas minor All. **Spiny Naiad**
ORCHIDACEAE
Pogonia ophioglossoides (L.) Juss. **Rose Pogonia**
Spiranthes cernua (L.) Rich. **Nodding Ladies'-tresses**
POACEAE (= GRAMINEAE)
Distichlis spicata (L.) Greene **Saltgrass; Spikegrass**
Elymus virginicus L. **Wild Rye**
Echinichloa crusgalli (L.) Beauv. **Barnyard Grass**
Glyceria canadensis (Michx.) Trin. **Rattlesnake Manna Grass**
Glyceria striata (Lam.) Hitchc. **Fowl Manna Grass**
Leersia oryzoides (L.) Swartz. **Rice Cut-grass**
Phalaris arundinacea L. **Reed Canary Grass**
Phragmites australis (Cav.) Trin. ex Steud. **Common Reed**
Panicum virgatum L. **Switchgrass**
Spartina alterniflora Loisel. **Saltmarsh Cordgrass**
Spartina cynosuroides (L.) Roth **Big Cordgrass**
Spartina patens (Aiton) Muhl. **Saltmeadow Cordgrass**
Zizania aquatica L. **Wild Rice**
PONTEDERIACEAE
Heteranthera dubia (Jacq.) MacM. **Water star-grass**
Pontederia cordata L. **Pickerelweed**

POTAMOGETONACEAE
Potamogeton amplifolius Tuckerm. **Broad-leaved Pondweed**
Potamogeton bicupulatus Fern. **Pondweed**
Potamogeton crispus L. **Curly Pondweed**
Potamogeton epihydrus Raf. **Pondweed**
Potamogeton gramineus L. **Pondweed**
Potamogeton illinoensis Morong **Illinois Pondweed**
Potamogeton natans L. **Floating-leaved Pondweed**
Potamogeton nodosus Poir. **American Pondweed**
Potamogeton oaksianus Robbins **Pondweed**
Potamogeton obtusifolius Mert. **Pondweed**
Potamogeton pectinatus L. **Sago Pondweed**
Potamogeton perfoliatus L. **Clasping-leaved Pondweed**
Potamogeton praelongus Wulfen **White-stemmed Pondweed**
Potamogeton pulcher Tuckerm. **Pondweed**
Potamogeton pusillus L. **Slender Pondweed**
Potamogeton richardsonii (Benn.) Rydb. **Richardson's Pondweed; Redhead**
Potamogeton robbinsii Oakes **Pondweed**
Potamogeton spirillus Tuckerman **Pondweed**
Potamogeton strictifolius Benn. **Pondweed**
Potamogeton vaseyi Robbins **Pondweed**
Potamogeton zosteriformis Fern. **Flat-stemmed Pondweed**
RUPPIACEAE
Ruppia maritima L. **Ditch-grass**
SPARGANIACEAE
Sparganium americanum Nuttall **Bur-reed**
Sparganium androcladum (Engelm.) Morong **Bur-reed**
Sparganium eurycarpum Engelm. **Bur-reed**
TYPHACEAE
Typha angustifolia L. **Narrow-leaved Cattail**
Typha latifolia L. **Broad-leaved Cattail**
XYRIDACEAE
Xyris torta Sm. **Twisted Yellow-eyed Grass**
ZANNICHELLIACEAE
Zannichellia palustris L. **Horned Pondweed**
ZOSTERACEAE
Zostera marina L. **Eelgrass**

YELLOW STAR THISTLE

(Centaurea solstitalis)

Pesticide Section

Though often misunderstood to refer only to ***insecticides*,** the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under United States law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant.

Specimen Label

SePRO

Sonar® SRP

Herbicide

A herbicide for management of aquatic vegetation in fresh water ponds, lakes, reservoirs, drainage canals, irrigation canals and rivers.

Active ingredient:

fluridone: 1-methyl-3-phenyl-5-[3-(trifluoromethyl) phenyl]-4(1H)-pyridinone.......5.0%
Inert ingredients.......95.0%
Total.......100.0%

Contains 2 pounds active ingredient per 40-pound container.

Keep Out of Reach of Children

CAUTION

Refer to inside of label booklet for additional precautionary information and Directions for Use.

Notice: Read the entire label before using. Use only according to label directions. **Before buying or using this product, read "Warranty Disclaimer" and "Limitation of Remedies" elsewhere on this label.**

In case of emergency endangering health or the environment involving this product, call collect 317-580-8282.

Specialty Chemical: Keep away from food, feedstuffs and water supplies.

EPA Reg. No. 67690-3 EPA Est. 39578-TX-1

900-003138

Trademark of SePRO Corporation
SePRO Corp. • Carmel, IN 46032 U.S.A.

Precautionary Statements

Hazards to Humans and Domestic Animals
Keep Out of Reach of Children

CAUTION

Harmful if Swallowed, Absorbed Through Skin, or if Inhaled

Avoid breathing of dust or contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling. Wash exposed clothing before reuse.

First Aid:

If in eyes: Flush eyes or skin with plenty of water. Get medical attention if irritation persists.
If swallowed: Call a physician or poison control center, drink one or two glasses of water and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person.
If inhaled: Remove victim to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.

Environmental Hazards

Follow use directions carefully so as to minimize adverse effects on nontarget organisms. In order to avoid impact on threatened or endangered aquatic plant or animal species, users must consult their State Fish and Game Agency or the U.S. Fish and Wildlife Service before making applications.

Do not contaminate water when disposing of equipment washwaters. Trees and shrubs growing in water treated with Sonar SRP may occasionally develop chlorosis. Do not apply in tidewater/brackish water.

Lowest rates should be used in shallow areas where the water depth is considerably less than the average depth of the entire treatment site, for example, shallow shoreline areas.

Directions for Use

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.
Read all Directions Carefully Before Applying Sonar SRP.

Storage and Disposal

Do not contaminate water, food or feed by storage or disposal.

Storage: Store in original container only. Do not store near feed or foodstuffs. In case of leak or spill, contain material and dispose as waste.

Sonar* SRP Herbicide

Be prepared in case of a fish kill. In this case, it even killed the catfish, which are harder to kill than mother-in-laws. Here an applicator sprayed too much product on the grass and the rain washed the active agent into the pond, killing all the fish. Be prepared to net and dispose of the dead fish and do whatever it takes to correct this situation. ***This situation or something like this will happen to you.*** You may not even know about it and this situation may be blamed on something else, but truth of the matter, it was the pesticide applicator trying to apply the correct dose and was wrong.

Read the label of the pesticide before buying or obtaining the product, before application and during storage and disposal of the container. Be careful with your triple-rinse water and always triple punch the can. Most of the groundwater pollution is from our pesticide containers. Don't get caught with an empty container in the back of your truck that is not triple rinsed and punched. All of us have done it, in some states like Arizona that is $1000.00 fine per container and the Applicator, the Qualifying Party, and the Business each get that fine.

If you have a good story that I can use, please send to me.

Aquatic Toxicology

Aquatic toxicology is the study of the effects of environmental contaminants on aquatic organisms, such as the effect of pesticides on the health of fish or other aquatic organisms. A pesticide's capacity to harm fish and aquatic animals is largely a function of its (1) toxicity, (2) exposure time, (3) dose rate, and (4) persistence in the environment.

Toxicity of the pesticide refers to how poisonous it is. Some pesticides are extremely toxic, whereas others are relatively nontoxic. Exposure refers to the length of time the animal is in contact with the pesticide. A brief exposure to some chemicals may have little effect on fish, whereas longer exposure may cause harm.

The dose rate refers to the quantity of pesticide to which an animal is subjected (orally, dermally, or through inhalation). A small dose of a more toxic chemical may be more damaging than a large dose of a less toxic chemical. Dosages can be measured as the weight of toxicant per unit (kilogram) of body weight (expressed as mg pesticide/kg of body weight) or as the concentration of toxicant in the water or food supply (usually expressed as parts per million, ppm or parts per billion, ppb).

A lethal dose is the amount of pesticide necessary to cause death. Because not all animals of a species die at the same dose (some are more tolerant than others), a standard toxicity dose measurement, called a Lethal Concentration 50 (LC50), is used. This is the concentration of a pesticide that kills 50% of a test population of animals within a set period of time, usually 24 to 96 hours.

Hazard ratings ranging from minimal to super toxic and LC50s for commonly used insecticides, herbicides, and fungicides are presented in Tables 3, 4 and 5. For example, the 24-hour LC50 of the insecticide permethrin to rainbow trout is 12.5 ppb. This means that one-half of the trout exposed to 12.5 ppb of permethrin died within 24 hours, indicating super toxicity of this pesticide to trout.

Hazard Ratings	
Toxicity	**LC50(mg/l)**
Minimal	>100
Slight	10 - 100
Moderate	1 - 10
High	0.1 - 1.0
Extreme	0.01 - 0.1
Super	< 0,01

Exposure of fish and other aquatic animals to a pesticide depends on its biological availability (bio-availability), bio-concentration, bio-magnification, and persistence in the environment.

Bioavailability refers to the amount of pesticide in the environment available to fish and wildlife. Some pesticides rapidly break down after application. Some bind tightly to soil particles suspended in the water column or to stream bottoms, thereby reducing their availability. Some are quickly diluted in water or rapidly volatize into the air and are less available to aquatic life.

Bioconcentration is the accumulation of pesticides in animal tissue at levels greater than those in the water or soil to which they were applied. Some fish may concentrate certain pesticides in their body tissues and organs (especially fats) at levels 10 million times greater than in the water.

Bio-magnification is the accumulation of pesticides at each successive level of the food chain. Some pesticides bio-accumulate (buildup) in the food chain. For example, if a pesticide is present in small amounts in water, it can be absorbed by water plants which are, in turn, eaten by insects and minnows. These also become contaminated. At each step in the food chain the concentration of pesticide increases. When sport fish such as bass or trout repeatedly consume contaminated animals, they bio-concentrate high levels in their body fat. Fish can pass these poisons on to humans.

Persistence of Pesticides

Persistence refers to the length of time a pesticide remains in the environment. This depends on how quickly it breaks down (degrades), which is largely a function of its chemical composition and the environmental conditions. Persistence is usually expressed as the "half life" (T1/2) of a pesticide. Half-life is the amount of time required for half of the pesticide to disappear (the other half remains). Half-life of pesticides can range from hours or days, to years for more persistent ones. Pesticides can be degraded by sunlight (photodecomposition), high air or water temperatures (thermal degradation), moisture conditions, biological action (microbial decay), and soil conditions (pH). Persistent (long-lasting) pesticides break down slowly and may be more available to aquatic animals.

Pesticide Formulations

The active ingredient (pesticide) is combined with other inert ingredients (carriers, solvents, propellants) to comprise the formulated pesticide product. In some cases the inert ingredients may cause concern for aquatic life. Pesticides may be purchased in solid (granules, powders, dusts) or liquid (water, oil sprays) form. A major concern in using either solid or liquid forms of pesticides is their misapplication.

Sub-lethal Effects

Not all pesticide poisonings result in the immediate death of an animal. Small "sub-lethal" doses of some pesticides can lead to changes in behavior, weight loss, impaired reproduction, inability to avoid predators, and lowered tolerance to extreme temperatures.

Fish in streams flowing through croplands and orchards are likely to receive repeated low doses of pesticides if continuous pesticide applications runoff fields. Repeated exposure to certain pesticides can result in reduced fish egg production and hatching, nest and brood abandonment, lower resistance to disease, decreased body weight, hormonal changes, and reduced avoidance of predators. The overall consequences of sub-lethal doses of pesticides can be reduced adult survival and lowered population abundance.

Sub-lethal Effects include:

- Weight Loss
- Low Diseases Resistance
- Sterility
- Reduced Egg Production
- Loss of Attention
- Low Predator Avoidance

Habitat Alteration
Pesticides can reduce the availability of plants and insects that serve as habitat and food for fish and other aquatic animals. Insect-eating fish can lose a portion of their food supply when pesticides are applied. A sudden, inadequate supply of insects can force fish to range farther in search of food, where they may risk greater exposure to predation.

How Fish are Exposed

Spraying herbicides can also reduce reproductive success of fish and aquatic animals. The shallow, weedy nursery areas for many fish species provide abundant food and shelter for young fish. Spraying herbicides near weedy nurseries can reduce the amount of cover and shelter that young fish need in order to hide from predators and to feed. Most young fish depend on aquatic plants as refuge in their nursery areas.

Aquatic plants provide as much as 80% of the dissolved oxygen necessary for aquatic life in ponds and lakes. Spraying herbicides to kill all aquatic plants can result in severely low oxygen levels and the suffocation of fish. Using herbicides to completely "clean up" a pond will significantly reduce fish habitat, food supply, dissolved oxygen, and fish productivity.

The landowner who sprays a weedy fence line with herbicides may unintentionally kill the trumpet vine on which hummingbirds feed and the honeysuckle that nourish deer and quail. Similarly, the landowner who unnecessarily sprays his water plants kills the plants that feed the insects that feed the fish that feed the farmer. Casual use of herbicides for lake or farm pond "beautification" may reduce fish populations.

Fish and aquatic animals are exposed to pesticides in three primary ways (1) dermally, direct absorption through the skin by swimming in pesticide-contaminated waters, (2) breathing, by direct uptake of pesticides through the gills during respiration, and (3) orally, by drinking pesticide-contaminated water or feeding on pesticide-contaminated prey. Poisoning by consuming another animal that has been poisoned by a pesticide is termed "secondary poisoning." For example, fish feeding on dying insects poisoned by insecticides may themselves be killed if the insects they consume contain large quantities of pesticides or their toxic byproducts.

Reducing the Risk: Prior to using a pesticide, consider the following:

1. Use a Pesticide Only When Necessary
   - Is the problem bad enough to justify the use of a toxic chemical? Are there alternative ways of treating the problem? Landowners should consider the costs and consequences of pesticide treatment relative to the problem.
2. Use Less Toxic Pesticides
   - One way to reduce the effects of pesticides on aquatic systems is to use those chemicals that are least poisonous to aquatic life. The tables presented at the end of this booklet give information about the relative toxicity of many of the agricultural pesticides. Select the least toxic material.
3. Use Safe/Sensible Application Methods
   - The first rule of responsible pesticide use is to read and then reread the pesticide label and follow the directions precisely. Label instructions sometimes can be confusing. If you don't understand the instructions, contact your Extension Agent, your supplier, or the pesticide company for more information.

- Pay particular attention to warning statements about environmental hazards on the label. Look for: "This product is toxic to fish." If you see such a warning, consider another pesticide or an alternative control method.
- Ensure that your application equipment is in good working condition. Check for leaks, replace worn parts, and carefully calibrate your equipment.
- When preparing the pesticides for application, be certain that you are mixing them correctly.
- Never wash spray equipment in lakes, ponds, or rivers. If you use water from natural ponds, lakes, or streams, use an antisiphon device to prevent backflow.
- If you are applying pesticides near water, check the label to find the recommended buffer zone. Buffer strip widths between the water and the treatment areas vary. Leave a wide buffer zone to avoid contaminating fish and aquatic animals.
- Store and dispose of unused chemicals and their containers according to the label instructions.
- Avoid pesticide drift into non-target areas, or applications during wet, windy weather that might promote runoff to non-target streams, ponds, or lakes. Spray on calm days, or early in the morning or evening when it is less windy.
- Pesticide applicators are liable for downstream fish kills and pesticide contamination.

Why Weeds:

- Excess Fertility
- Shallow Water
- Exotic Invaders
- Fast Reproduction

Insecticide Safety Precautions

The Federal Environmental Pesticide Control Act of 1972 in part prohibits the application of any pesticide in a manner inconsistent with its labeling. This means that a pesticide cannot be used unless it is registered for the specific pest. Consequently, some chemicals formerly used by homeowners and pesticide applicators can no longer be used legally.

Insecticide labels are subject to change, and changes may have occurred since this publication was printed. County Extension agents and extension entomologists are notified as these changes occur.

The pesticide **APPLICATOR** is always responsible for the effects of pesticide residues as well as problems caused by residues that drift from the application site to other property. Always read and carefully follow instructions on the product label.

When using pesticides, always avoid prolonged chemical contact with skin. Wash exposed skin areas with generous amounts of soap and water. Launder clothing worn during application in hot water using a phosphate detergent. Do not contaminate food, dishes, utensils or food preparation areas with insecticide. Any contaminated food should be discarded, and dishes and utensils should be thoroughly washed.

Safety Notes

- **READ, UNDERSTAND** and **FOLLOW** all insecticide label directions and precautions. Some product labels may require that pilot lights should be off on stove, furnace and water heater.
- Keep insecticides in original containers with the label intact. Do not contaminate food, water, dishes or utensils.
- Keep insecticides out of reach of children and do not allow children or pets near treated surfaces until dry.

Bull Snake

The Bull Snake, Pituophis melanoleucus, is a hissing constrictor from North America. This snake is also called the gopher snake (in western North America) and the pine snake (in eastern North America). Often found near ponds and lakes.

Gopher Snake

(Pituophis melanoleucus) can be mistaken for rattlesnakes because of their dark dorsal patches on their generally yellow or cream bodies. They are not venomous snakes, however, killing their prey (rodents, rabbits, insects, birds and their eggs, and lizards) by constriction. They sometimes raise and shake their tail, hissing and playing up their resemblance to rattlesnakes. They have small heads, however, without the larger, more triangular head of a rattlesnake. The snout is somewhat pointed and there is an enlarged scale which extends upward between the nostrils. The scales are keeled, and the snakes range from 48-100 inches (122-254 cm) in length (MacMahon, 1985).

I. DESCRIPTION:
Skin is patterned in golds and reddish-browns. Adults reach four and a half feet.

II. GEOGRAPHICAL RANGE AND HABITAT:
Southern British Columbia and throughout much of the western portion of the United States. Found in open woodlands, plains, agricultural areas - everywhere except high mountains.

III. DIET:
Mice, rabbits, ground squirrels, pocket gophers. Kills by constriction.

IV. LIFE CYCLE/SOCIAL STRUCTURE:
Usually active by day, but nocturnal in hot weather. Mates in the spring. Up to 24 eggs are laid in a burrow or beneath a rock or log. Eggs hatch in 9-11 weeks.

V. SPECIAL ADAPTATIONS:
The scale on the tip of the snake's snout is enlarged upward on the head; this modification is probably because of its partly burrowing habits. They burrow underground for shelter or take over a mammal or tortoise burrow.

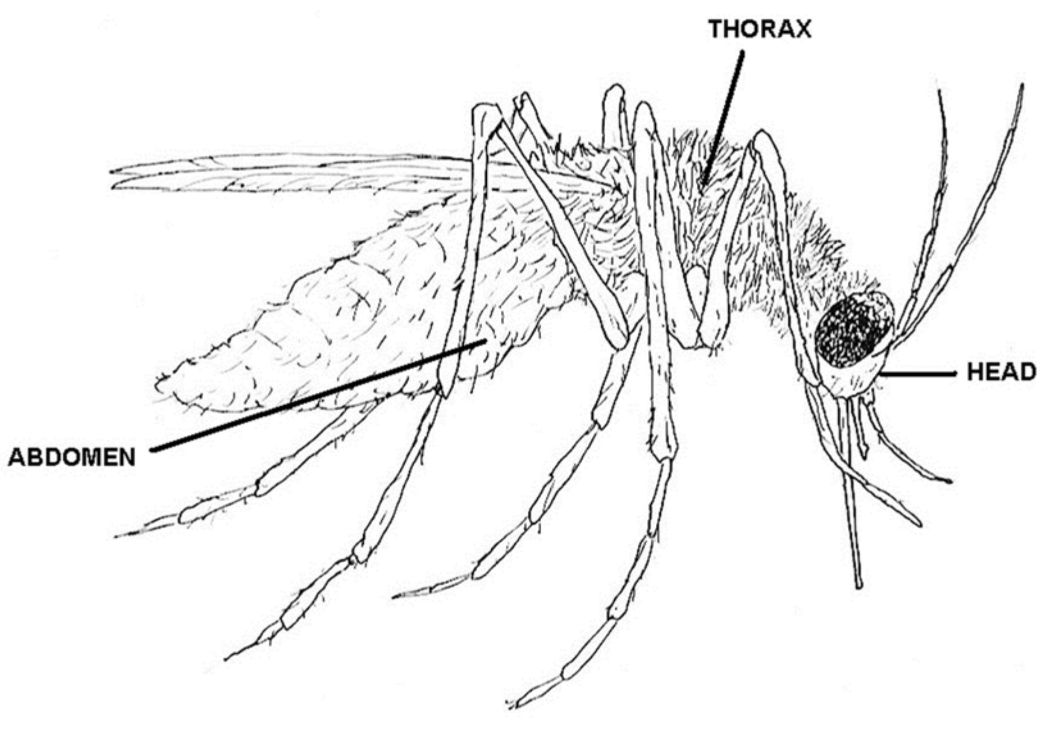
VI. INTERPRETIVE INFORMATION:
The gopher snake is a close relative of the pine and bull snakes, and all are of great benefit to farmers because of the number of rodents they eat. If the snake is threatened and cannot get away, it will face the threat with a flattened head, coil in s-loops, and vibrate its tail. It also inhales a large amount of air so that it looks larger and will release this air in loud hissing noises accompanied by strikes.

Mosquito Section

Because most of us work for or near a wastewater treatment facily, we need to be able to identifiy and control various mosquitoes. Especially with the serious diseases like Zika virus.

What is Zika virus disease (Zika)?
Zika is a disease caused by Zika virus that is spread to people primarily through the bite of an infected *Aedes* species mosquito. The most common symptoms of Zika are fever, rash, joint pain, and conjunctivitis (red eyes). The illness is usually mild with symptoms lasting for several days to a week. People usually don't get sick enough to go to the hospital, and they very rarely die of Zika

Is this a new virus?
No. Outbreaks of Zika previously have been reported in tropical Africa, Southeast Asia, and the Pacific Islands. Zika virus likely will continue to spread to new areas. In May 2015, the Pan American Health Organization (PAHO) issued an alert regarding the first confirmed Zika virus infection in Brazil. Since that time, local transmission has been reported in many other countries and territories.



MOSQUITO

Mosquitoes are the #1 killer of humans in the world. About 2 million people die each year from one disease resulting from a mosquito bite. The disease is called Malaria, and is caused by a small animal, called a *Plasmodium,* that gets into people through a mosquito bite.

Only female mosquitoes bite. They use protein from blood to make the shells of their eggs. Male and female mosquitoes eat nectar from flowers, like butterflies and hummingbirds. The female mosquitoes have a problem, though, when they try to suck our blood. When our blood gets outside of our body, the cells tend to stick together.

We know this as “clotting” and it's why you get a scab when you cut yourself, its scientific name is "coagulation". Coagulation is a big problem for a mosquito who has a very thin tube through which to suck blood.

The coagulated blood cells clog her tube and she cannot get good blood through it. To combat coagulation, the mosquito first *spits* into us when she bites. She spits a chemical called an "anti-coagulant" that keeps the blood cells from sticking together so she can suck as much as she wants! It is during the spitting phase of biting that the Malarial *Plasmodium* gets into us.

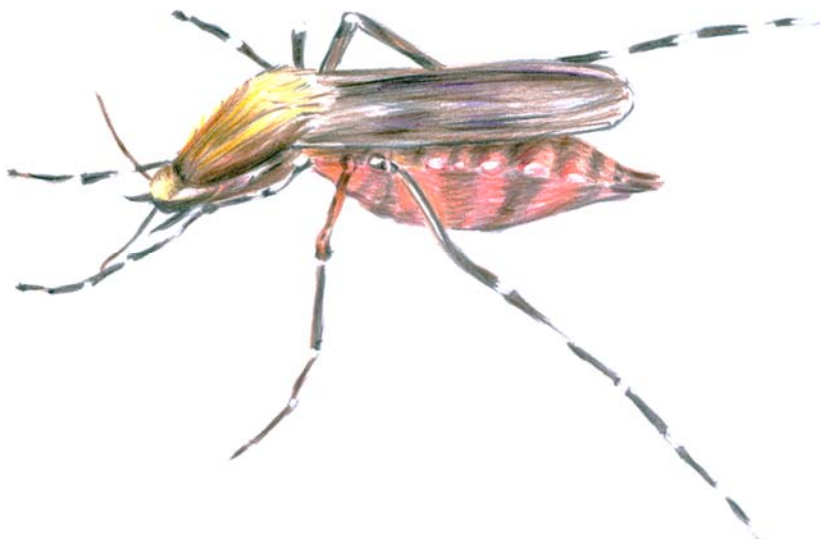
Once inside a mammal, the *Plasmodium* goes through the bloodstream and into the liver, where it reproduces. From the liver, the *Plasmodium* cells get into red blood cells and begin to feed. Inside the red blood cells, the *Plasmodium* cells divide and eventually split the red blood cells open, and a bunch of new *Plasmodium* cells infect other red blood cells.

The cycle continues as the host animal gets sicker and sicker, and often dies. Fortunately, the type of *Plasmodium* that causes malaria and the species of mosquito (in the genus *Anopheles* "an-off-eh-lees") that spreads it do not live in the United States, but in many other countries (especially in tropical regions), this is a very dangerous disease. Therefore, a lot of research money is available for the study of malaria and mosquitoes (which also spread other diseases in much the same fashion).

Terms and Definitions

Mosquito (*Death from Above*)

Any one of various species of gnats of the genus Culex and allied genera. The females have a proboscis containing, within the sheath-like labium, six fine, sharp, needlelike organs with which they puncture the skin of man and animals to suck the blood. These bites, when numerous, cause (in many persons) considerable irritation and swelling, with some pain. The larv[ae] and pup[ae], called wigglers, are aquatic. A mosquito has three body parts; the head, the thorax, and the abdomen. It has six legs, two wings, and two antennae. (The male and female have different antennae.) The part that sucks our blood is called the proboscis.

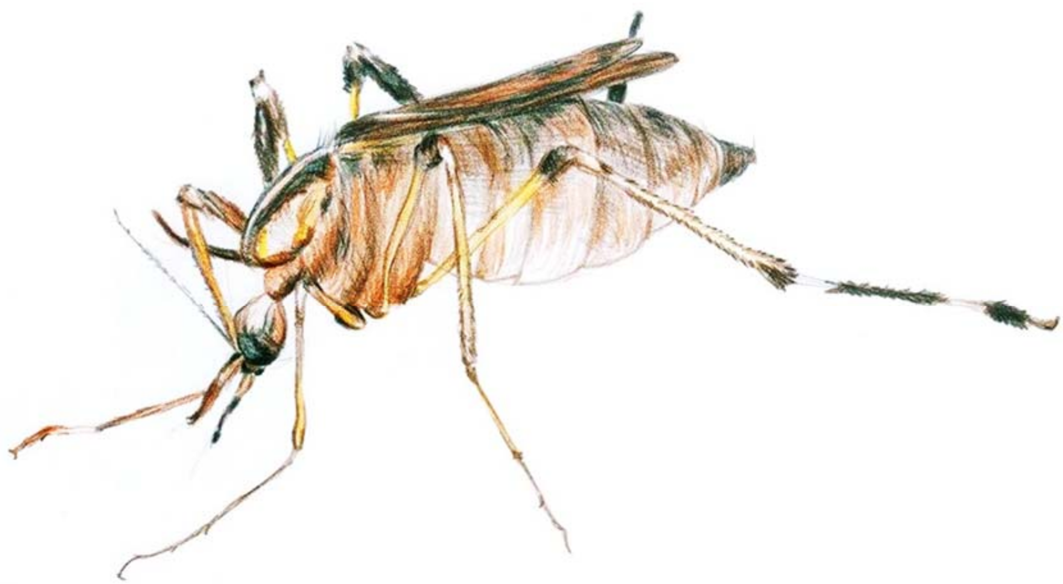


Blood engorged female

Term	**Definition**
Arbovirus	Any of various viruses transmitted by arthropods and including the causative agents of encephalitis, yellow fever, and dengue.
Biological Control	The use of parasites or pathogens to control a pest.
Disease	Condition of the living animal or plant body or of one of its parts that impairs the performance of a vital function.
Encephalomyelitis	Concurrent inflammation of the brain and spinal cord.
Monitoring	Method in which an area is appraised for its mosquito numbers and/or evidence of disease agents within the mosquito population.
Pathogen	Specific causative agent of disease.
Reservoir	Organism in which a parasite that is pathogenic for some other species lives and multiplies without damaging its host.
Surveillance	Method in which an area is appraised for its risk of providing mosquito breeding grounds and subsequent mosquito populations.
Vector	Organism that transmits a pathogen.

Aedes vexans

Floodwater mosquitoes, such as *Aedes vexans,* lay their eggs in damp places just above the water line of temporary ponds. The eggs hatch after a warm rain and may produce a new generation of adults in as little as a week. Eggs can also remain dormant for over two years during drought conditions. The adults will die from desiccation if exposed to dry sunny conditions and will only emerge from wooded areas at dusk or on dull, humid days.



Psorophora ciliata

Psorophora ciliata is found only during wet summers when other mosquitoes are abundant. Their larvae are carnivorous and each one consumes dozens of smaller mosquito larvae.

Mosquito Introduction

How Many Kinds of Mosquitoes Are There?
About 3,000 species of mosquitoes have been described on a world-wide basis. Approximately 150-200 are known to occur in North America. Scientists group species by genus on the basis of the physical characteristics they share. The 3,000 mosquito species found in the world are divided among 28 different genera. The genus *Aedes* contains some of the worst pests. Many members of the genus *Anopheles* have the ability to transmit human malaria.

Mosquito Genera
Here are just a few major genera that occur in the United States: *Aedes*, *Anopheles*, *Culex*, *Culiseta*, *Coquillettidia*, *Psorophora*, *Orthopodomyia*, *Uranotaenia*, *Toxorhynchites* and *Wyeomyia*. It is sometimes more convenient to group mosquitoes by the breeding habitat they use. The major habitat groups found include: "*Snowpool Mosquitoes,* "*Floodwater Mosquitoes,"* "*Swamp Breeding Mosquitoes,*" and "*Container Breeding Mosquitoes.*

Common Name	Scientific Name	Importance
Asian Tiger Mosquito	Aedes albopictus	LAC, EEE, SLE, Pest
Banded spring mosquito	Aedes canadensis	LAC, Pest
Eastern Treehole Mosquito	Aedes triseriatus	LAC
Flood-water mosquito	Aedes tivittatus	Pest
Vexans Mosquito	Aedes vexans	Pest
Common Malaria Mosquito	Anopheles quadrimaculatus	Malaria, Pest
Cattail Mosquito	Coquillettidia perturbans	EEE, Pest
Northern House Mosquito	Culex pipiens	SLE
Key: **LAC** = LaCrosse Encephalitis **EEE** = Eastern Equine Encephalomyelitis **SLE** = St. Louis Encephalitis		

World's Deadest Insect/Animal of all Time
Mosquitoes are estimated to transmit disease to more than 700 million people annually in Africa, South America, Central America, Mexico, Russia and much of Asia with millions of resulting deaths. At least 2 million people annually die of these diseases. Mosquitoes are a vector agent that carries disease-causing viruses and parasites from person to person without exhibiting symptoms themselves. The principal mosquito borne diseases are the viral diseases yellow fever, dengue fever and Chikungunya, transmitted mostly by the Aedes aegypti, and malaria carried by the genus Anopheles. Though originally a public health concern, HIV is now thought to be almost impossible for mosquitoes to transmit.

Methods used to prevent the spread of disease, or to protect individuals in areas where disease is endemic include Vector control aimed at mosquito eradication, disease prevention, using prophylactic drugs and developing vaccines and prevention of mosquito bites, with insecticides, nets and repellents. Since most such diseases are carried by "elderly" females, scientists have suggested focusing on these to avoid the evolution of resistance

Mosquito control requires knowledge of the behavioral and habitat differences among species in order to plan and carry out a treatment program. The trained worker first identifies the problem species. With identity established, useful correlations are immediately available, such as the type of breeding habitat and where to search for larvae. A working knowledge of the behavior and habitats frequented by various species aids in determining the kinds of survey and control strategies best suited for the task. Mosquitoes are not adapted to life in moving waters, but they can occupy the quiet pools and seepage areas near flowing streams.

Aquatic Environments
Aquatic environments differ chiefly in the chemistry of the water (acid or alkaline; fresh, salt or brackish). These environments may be natural or man-made and may also differ in the amount or type of vegetation present and the amount of sun or shade. Coquillettidia perturbans, Mansonia dyari and Ma. titillans, for example, are found in association with specific aquatic plants — water lettuce, water hyacinth and cattails. Wyeomyia spp. are found in association with bromeliads and pitcher plants. In this regard, the distinctive egg-laying habit of each species of mosquito determines its larval habitat. Although some species use more than one type of habitat, most mosquitoes can be categorized in general terms by their preference for either permanent water, floodwater, transient water or artificial container and tree-hole habitats. These categories can be combined into two major larval habitat categories: standing water (permanent and transient) and floodwater (including natural and artificial containers as well as floodwater).

Standing water species deposit their eggs (either singly or in rafts) on the surface of permanent or transient pools of standing water. They usually produce several generations (broods) each year and overwinter or survive harsh environmental circumstances as mated, engorged females. In contrast, floodwater species deposit their eggs out of the water but in locations subject to periodic flooding, such as damp soil in depressions or inside tree holes, crab holes and artificial containers. They produce one to several broods annually and overwinter or survive harsh environmental circumstances in the egg stage. Mosquitoes are adaptable to changing environmental conditions and are thus associated with multiple habitat types.

Why do Mosquitoes Bite?
Mosquitoes belong to a group of insects that require blood to develop fertile eggs. Males do not lay eggs, thus, male mosquitoes do not bite. The females are the egg producers and "*host-seek*" for a blood meal. Female mosquitoes lay multiple batches of eggs and require a blood meal for every batch they lay. Few people realize that mosquitoes rely on sugar as their main source of energy.

Both male and female mosquitoes feed on plant nectar, fruit juices, and liquids that ooze from plants. The sugar is burned as fuel for flight and is replenished on a daily basis. Blood is reserved for egg production and is imbibed less frequently.

Why do Mosquitoes Leave Welts When they Bite?
When a female mosquito pierces the skin with her mouthparts, she injects a small amount of saliva into the wound before drawing blood.

Adult mosquitoes are terrestrial and capable of flight. With piercing-sucking mouthparts, the females feed mostly on animal blood and plant nectar. Males' antennae have dense bristles, and their mouthparts are modified to suck nectar and plant secretions, where no piercing is required. The adults of some species remain within a few hundred feet of where they spent the larval stage, whereas others may migrate up to 50 miles or more.

Eggs develop a few days after females take a blood meal. Females oviposit on the water, in crevices in the soil, or on other favored substrates or special niches that are or will subsequently be flooded, such as natural and artificial containers or tree holes, and the cycle repeats itself. Females of some floodwater species may live up to a month after they emerge, whereas those of some permanent water or standing water species can survive for several months by overwintering as mated, engorged adults. Some species, including those whose eggs require freezing temperatures, are limited to a single generation per year, whereas others have multiple generations.

Those casually acquainted with mosquitoes may believe that all types are much the same, and, indeed, the similarities between species is considerable. There are, however, many differences in appearance from species to species and even among some varieties within species.

These morphological differences, especially notable in the larval and adult stages, permit accurate identification of most species. Behavioral differences permit various species to occupy numerous ecological niches with relatively little overlap. Thus, knowledge of the source or breeding habitat of mosquitoes can provide strong clues to their identification.

Why are some People More Attractive to Mosquitoes than others?
Scientists are still investigating the complexities involved with mosquito host acceptance and rejection. Some people are highly attractive to mosquitoes and others are rarely bothered. Mosquitoes have specific requirements to satisfy and process many different factors before they feed.

Many of the mosquito's physiological demands are poorly understood and many of the processes they use to evaluate potential blood meal hosts remain a mystery. Female mosquitoes use the CO_2 we exhale as their primary cue to our location. A host-seeking mosquito is guided to our skin by following the slip stream of CO_2 that exudes from our breath.

Short Range Attractants
Once they have landed, they rely on a number of short-range attractants to determine if we are an acceptable blood meal host. Folic acid is one chemical that appears to be particularly important. Fragrances from hair sprays, perfumes, deodorants, and soap can cover these chemical cues. They can also function to either enhance or repel the host-seeking drive. Dark colors capture heat and make most people more attractive to mosquitoes. Light colors refract heat and are generally less attractive to mosquitoes. Detergents, fabric softeners, perfumes and body odor can counteract the effects of color. In most cases, only the mosquito knows why one person is more attractive than another.

How Long Do Mosquitoes Live?
Mosquitoes are relatively fragile insects with an adult life span that lasts about 2 weeks. The vast majority meets a violent end by serving as food for birds, dragonflies, and spiders, or are killed by the effects of wind, rain or drought. The mosquito species that only have a single generation each year are longer lived and may persist in small numbers for as long as 2-3 months if environmental conditions are favorable. Mosquitoes that hibernate in the adult stage live for 6-8 months, but spend most of that time in a state of torpor. Some of the mosquito species found in arctic regions enter hibernation twice and take more than a year to complete their life cycle.

What Happens When Mosquitoes Bite?
The saliva makes penetration easier and prevents the blood from clotting in the narrow channel of her food canal. The welts that appear after the mosquito leaves is not a reaction to the wound but an allergic reaction to the saliva injected to prevent clotting. In most cases, the itching sensation and swellings subside within several hours. Some people are highly sensitive and symptoms persist for several days. Scratching the bites can result in infection if bacteria from the fingernails are introduced to the wounds.

Where do mosquitoes go in the winter?
Mosquitoes, like most insects, are cold-blooded creatures. As a result, they are incapable of regulating body heat, and their temperature is essentially the same as their surroundings. Mosquitoes function best at 80°F, become lethargic at 60°F and cannot function below 50°F.

Saliva
In order for the mosquito to obtain a blood meal it must circumvent the vertebrate physiological responses. The mosquito, as with all blood-feeding arthropods, has mechanisms to effectively block the hemostasis system with their saliva, which contains a mixture of secreted proteins. Mosquito saliva negatively affects vascular constriction, blood clotting, platelet aggregation, angiogenesis and immunity and creates inflammation. Universally, hematophagous arthropod saliva contains at least one anticlotting, one anti-platelet, and one vasodilatory substance. Mosquito saliva also contains enzymes that aid in sugar feeding and antimicrobial agents to control bacterial growth in the sugar meal. The composition of mosquito saliva is relatively simple as it usually contains fewer than 20 dominant proteins.

Despite the great strides in knowledge of these molecules and their role in bloodfeeding achieved recently, scientists still cannot ascribe functions to more than half of the molecules found in arthropod saliva. One promising application is the development of anti-clotting drugs based on saliva molecules, which might be useful for approaching heart-related disease, because they are more user-friendly blood clotting inhibitors and capillary dilators.

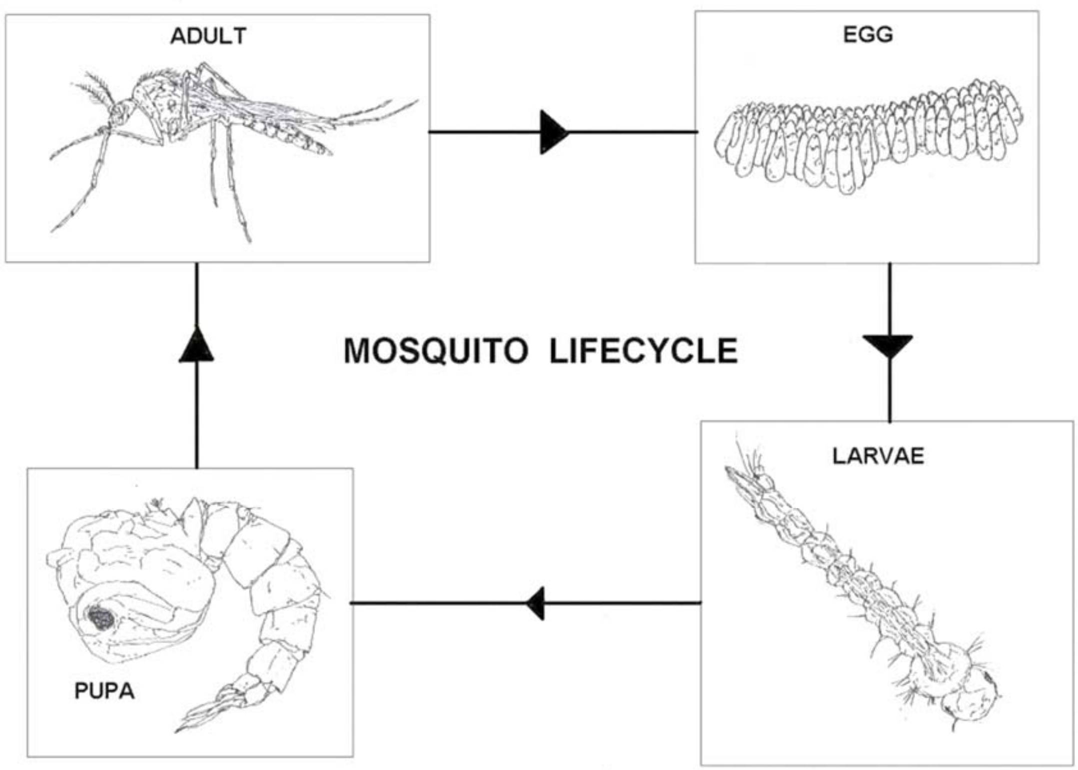
Modulate the Immune Response
It is now well recognized that the feeding ticks, sandflies, and, more recently, mosquitoes have an ability to modulate the immune response of the animals (hosts) they feed on. The presence of this activity in vector saliva is a reflection of the inherent overlapping and interconnected nature of the host hemostatic and inflammatory/immunological responses and the intrinsic need to prevent these host defenses from disrupting successful feeding. The mechanism for mosquito saliva-induced alteration of the host immune response is unclear, but the data has become increasingly convincing that such an effect occurs.

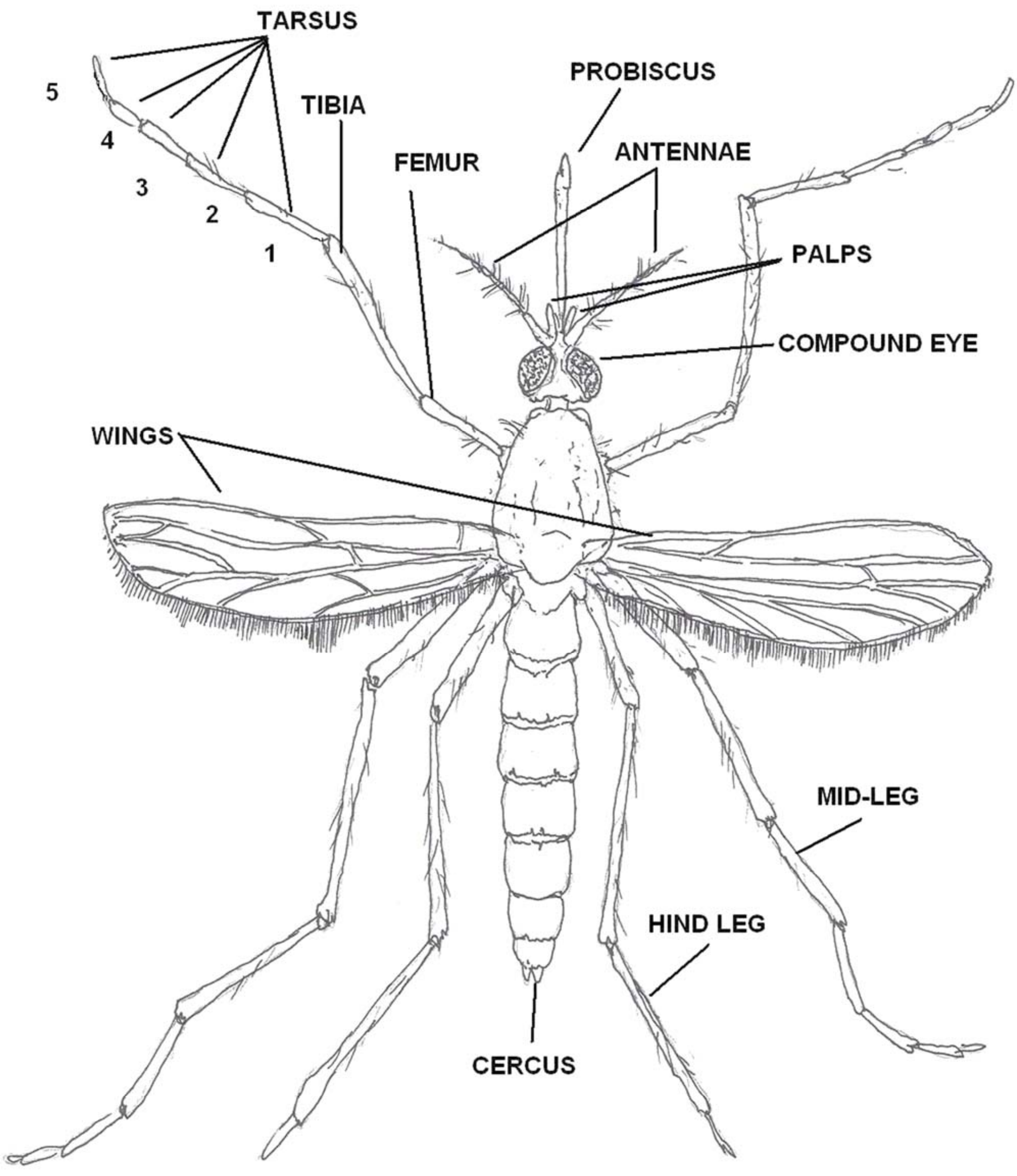
Early work described a factor in saliva that directly suppresses TNF release, but not antigen-induced histamine secretion, from activated mast cells. Experiments by Cross et al. (1994) demonstrated that the inclusion of Ae. aegypti mosquito saliva into naïve cultures led to a suppression of interleukin (IL)-2 and IFN production, while the cytokines IL-4 and IL-5 are unaffected by mosquito saliva. Cellular proliferation in response to IL-2 is clearly reduced by prior treatment of cells with SGE. Correspondingly, activated splenocytes isolated from mice fed upon by either Ae. aegypti or Cx. pipiens mosquitoes produce markedly higher levels of IL-4 and IL-10 concurrent with suppressed IFN production. Unexpectedly, this shift in cytokine expression is observed in splenocytes up to 10 days after mosquito exposure, suggesting that natural feeding of mosquitoes can have a profound, enduring, and systemic effect on the immune response.

A recent study suggests that mosquito saliva can also decrease expression of interferon during early mosquito-borne virus infection. The contribution of type I interferons (IFN) in recovery from infection with viruses has been demonstrated in vivo by the therapeutic and prophylactic effects of administration of IFN-inducers or IFN, and recent research suggests that mosquito saliva exacerbates West Nile virus infection, as well as other mosquito-transmitted viruses.

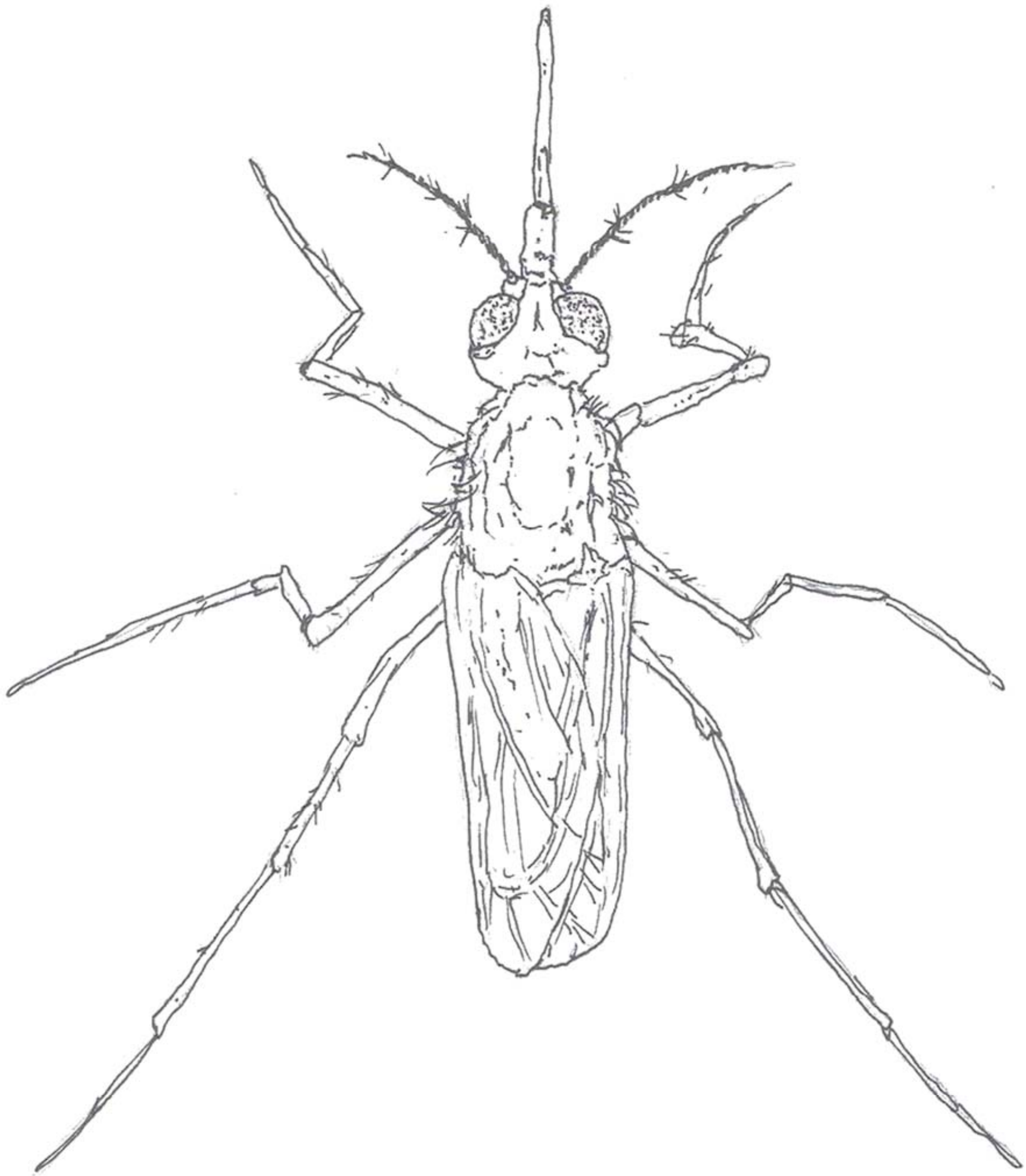
Canine Heartworm

Dogs are quite susceptible to canine heartworm, a nematode that can be transmitted by certain mosquitoes. Infected animals may develop severe circulatory problems and display symptoms such as coughing, labored breathing, and loss of vitality. Preventive drug treatment is available through your veterinarian.





MOSQUITO ANATOMY



MOSQUITO (CULICIDAE FAMILY)

Mosquito Family, Subfamily, Genus and Related Classifications

Aedes

Aedes is a genus of mosquito originally found in tropical and subtropical zones, but now found on all continents excluding Antarctica. Some species have been spread by human activity. Aedes albopictus, a most invasive species was recently spread to the new world, including the US, by the used tire trade. First described and named by Meigen in 1818, the name comes from the Ancient Greek word, meaning "unpleasant" or "odious". Some species of this genus transmit serious diseases, including dengue fever and yellow fever. In Polynesia, the species Aedes polynesiensis is responsible for the transmission of human lymphatic filariasis including species of Brugia as well as others. Aedes can be detected and monitored by Ovitraps.

Anopheles (Genus)

Subfamily Anophelinae. A total of 465 formally recognized species and more than 50 unnamed members of species complexes are recognized as distinct morphological and/or biological species of the genus. The formally named species are placed in seven subgenera, Anopheles (182 species), Baimaia (1), Cellia (217), Kerteszia (12), Lophopodomyia (6), Nyssorhynchus (35) and Stethomyia (5).

World-Wide Distribution

Anopheles has an almost world-wide distribution. Species of the genus occur in temperate, subtropical and tropical areas, but are absent from the majority of the Pacific Islands, including the large ones of New Zealand, Fiji and New Caledonia, and isolated islands in the Atlantic. Anopheles species are found at elevations from coastal areas to mountainous terrain.

Mosquitoes of genus Anopheles are the sole vectors of human malarial parasites. Some species are effective vectors of microfilariae and some may be involved in the transmission of encephalitis viruses. Anopheles are vectors of numerous animal pathogens, including species of malaria protozoa that do not affect humans.

Largest Subgenus

Cellia is the largest subgenus with all species occurring in the Old World. The subgenus is segregated into six Series (Cellia, Neocellia, Myzomyia, Neomyzomyia, Paramyzomyia and Pyretophorus). Each series contains vectors of malarial protozoa and microfilariae. The most important malaria vectors include An. arabiensis, An. funestus, An. gambiae and An. moucheti in the Afrotropical Region; An. balabacensis, An. baimaii, An. culicifacies, An. dirus, An. latens, An. leucosphyrus, An. maculatus, An. minimus, An. fluviatilis s.l., An. sundaicus and An. superpictus in the Oriental Region; members of the An. farauti and An. punctulatus complexes in the Australasian Region; An. sergentii and An. stephensi in the Middle East and the Indian Subcontinent.

Anopheles

Subgenus Anopheles is also divided into six series, but only the Myzorhynchus and Anopheles Series contain vector species. Some primary vectors of historical and contemporary importance in the transmission of malaria protozoa include An. freeborni in western North America, An. sinensis in southeastern areas of the Palaearctic Region, An. atroparvus in Europe and eastern Asia, and An. pseudopunctipennis at higher elevations in Central and South America.

Nyssorhynchus
Subgenus Nyssorhynchus contain species that are variously distributed from Argentina to the southern USA. Anopheles albimanus, An. aquasalis, An. argyritarsis, An. darlingi and An. nuneztovari are vectors of malarial protozoa. Anopheles albitarsis and An. aquasalis also transmit arboviruses, and some species also transmit Wuchereria bancrofti.

Kerteszia
Subgenus Kerteszia occurs in Central and South America. Six species are known to transmit malarial protozoa, but only An. bellator in Trinidad and An. cruzii in Brazil are important vectors. Anopheles bellator also transmits the helminths that cause Bancroftian filariasis.

Species of the remaining subgenera, Baimaia in the Oriental Region and Stethomyia and Lophopodomyia in the Neotropical Region, are not of medical importance to humans.

Anophelinae (Genus subfamily)
Subfamily Anophelinae includes 478 formally recognized species. Many genetic species of sibling species complexes await formal names. The subfamily is divided into three genera: Anopheles, Bironella and Chagasia. Mosquitoes belonging to these genera are referred to as 'anophelines' Most species of the subfamily belong to genus Anopheles, which occurs in temperate, subtropical and tropical areas of the world except for island groups in the Pacific and isolated islands in the Atlantic. Bironella and Chagasia are small genera, restricted to the Australasian and Neotropical Regions, respectively. Adult anophelines are easily recognized by their appearance. Most species stand with the body inclined at an angle of 30-45° to the surface and have dark and pale spots of scales on the veins of the wings. Some species have the wing veins entirely covered with dark scales. The maxillary palpi of both sexes are about as long as the proboscis (except in Bironella). The palpi of females sometimes have semi-erect scales that give them a rather shaggy appearance. The scutellum is evenly rounded in Anopheles and Bironella and tri-lobed in Chagasia. The abdominal sterna, and usually the terga, are completely or nearly devoid of scales. Anopheline larvae lack a respiratory siphon, the head is longer than wide and pairs of palmate setae are normally present on some or all of abdominal segments I-VII.

Chagasia (Genus)
Chagasia is a small genus of only five species. Four species of Chagasia are restricted to South America and one (Ch. bathana) extends from Ecuador, Colombia and Venezuela through Central America into southern Mexico. Chagasia has been considered an ancient group showing affinities with non-anophelines. Cladistic analyses of morphological data and DNA sequences of various ribosomal, mitochondrial and nuclear genes strongly support the monophyly of Chagasia and its placement in an ancestral relationship to all other anophelines.

Similar to Anopheles
The adults of Chagasia are similar to those of Anopheles, but the resting posture is like culicine mosquitoes with the head and abdomen at angles to the thorax, and the scutellum is tri-lobed with setae in three distinct groups.

The wings have dark scales or a mixture of dark and pale scales, but there are no distinct spots as there are in most Anopheles. Larvae have uniquely shaped palmate setae (seta 1) on abdominal segments III-V, and the spiracular apparatus bears a long median process and a fringe-like row of setae on either side. See Anophelinae.

Chagasia larvae are usually found in shaded streams among the roots of trees and in grassy margins or dead leaves and other debris. They sometimes occur in clear rock-pools along shaded streams. Adults remain in vegetation near the larval habitats or enter nearby forest canopy. Females bite during the day and night, but seldom feed on humans. Species of Chagasia are not known to transmit any pathogens of human diseases.

Chironomidae (Chironomidae family) (Non-Biting Midges)

Chironomidae (informally known as chironomids or non-biting midges) are a family of nematoceran flies with a global distribution. They are closely related to the Ceratopogonidae, Simuliidae, and Thaumaleidae. Many species superficially resemble mosquitoes but they lack the wing scales and elongate mouthparts of the Culicidae. This is a large group of insects with over 5000 described species and 700 species in North America alone.

Plumose Antennae

Males are easily recognized by their plumose antennae. Adults are sometimes known as "lake flies" in parts of Canada, as "sand flies", "muckleheads", or "muffleheads" in various regions of the USA Great Lakes area, and as "blind mosquitoes" or "chizzywinks" in Florida, USA. Their amazing biodiversity often goes unnoticed because Chironomidae are notoriously difficult to identify and are usually recorded by species groups by ecologists. Each morphologically distinct group consists of a number of morphologically (sibling) identical species that can only be identified by rearing adult males or by cytogenetic analysis of the polytene chromosomes.

Polytene chromosomes were originally observed in the larval salivary glands of Chironomus midges by Balbiani in 1881. They form through repeated rounds of DNA replication without cell division, resulting in characteristic light and dark banding patterns which can be used to identify inversions and deletions which allow species identification.

Bloodworms

Larval stages of Chironomidae can be found in almost any aquatic or semiaquatic habitat, including treeholes, bromeliads, rotting vegetation, soil, and in sewage and artificial containers. They form an important fraction of the macro zoobenthos of most freshwater ecosystems. They are often associated with degraded or low biodiversity ecosystems because some species have adapted to virtually anoxic conditions and are dominant in polluted waters. Larvae of some species are bright red in color due to a hemoglobin analog; these are often known as "bloodworms". Their ability to capture oxygen is further increased by making undulating movements.

Adults can be pests when they emerge in large numbers. They can damage paint, brick, and other surfaces with their droppings. When large numbers of adults die they can build up into malodorous piles. They can provoke allergic reactions in sensitive individuals

Culex

Carl Linnaeus used the Latin term for midge or gnat, culex, as the name of this taxon. Culex is a genus of mosquito, and is important in that several species serve as vectors of important diseases, such as West Nile virus, filariasis, Japanese encephalitis, St. Louis encephalitis and avian malaria. The adult mosquito can measure from 4–10 millimeters (0.16–0.39 in), and morphologically has the three body parts common to insects: head, thorax, and abdomen. As a fly, it has one pair of wings. Scientists at the University of California, Davis and the Swedish University of Agricultural Sciences (SLU), have identified nonanal as a compound that attracts Culex mosquitoes. Nonanal acts synergistically with carbon dioxide. The developmental cycle takes two weeks and is by complete metamorphosis. Eggs are laid singularly or in batches, depending on the species. Eggs will only hatch in the presence of water. During the larval stage the mosquito lives in water and feeds on organic matter and plants, then develops into a pupa. The pupa is comma-shaped and also lives in water. It does not feed and becomes an adult after one or two days.

Culex Tarsalis

Tarsalis is a North American species of mosquito that occupies a large swath of territory between northern Mexico and southern Canada, spreading from the Pacific to the Atlantic coast. It is most commonly seen in California, at elevations ranging as high as 3000 meters. The species is much less abundant in areas east of the Mississippi River, although there have been several reported cases of C. tarsalis occurrences as far as New Jersey, which were found exploiting freshwater impoundments constructed to eliminate the salt marsh species Aedes sollicitans. (Crans and McCuiston, 1987; Reisen, 1993)

Associated Species

Larval habitats frequently are shared with Culiseta inornata, Culex quinquefasciatus, Cx. pipiens and Cx. stigmatosoma; other species include Culex erythrothorax, Cx. restuans and several species of Aedes and Anopheles.

Rafts

Rafts averaging about 190 eggs are oviposited in newly-created sunlit surface water pools that are frequently surrounded by grasses and annual vegetation. Larvae tolerate a wide range of water conditions and may be abundant in agricultural tailwater, alkaline lake beds, fresh and saline wetlands, secondary treated sewage effluent and oil field run-off. Permanent water with fixed depth rarely supports abundant populations unless intermittently perturbated. Excessive organic pollution is not tolerated.

Cx. tarsalis are among the first colonizers of newly-created surface pools and thus exploit microfloral blooms produced by the release of nutrients from decomposing vegetation. Larval development ranges from 7 days to <4 weeks and progresses as a curvilinear function of water temperature and food availability. Larval survivorship is typically <5%, with most losses attributable to predation.

Some females mature their initial egg batch without a blood meal and oviposit 4-5 days after emergence. The frequency of this trait is dependent upon temperature, photoperiod and nutrition and affects the vectorial capacity of a population. At northern latitudes, females overwinter in facultative diapause as inseminated nullipars (never developed eggs) that require a blood meal to produce their initial eggs in the spring.

Blood Feeding
In spring, when population abundance is low, most females feed on birds shortly after sunset. During late summer when abundance is high, bird mosquito-avoidance behavior diverts many females to feed on mammals including rabbits, horses, cattle and man. This host shift may be important in virus transmission to horses and man. Dispersal is primarily during host-seeking flights (up to 17 miles) which average about l00 yards a day from breeding sites in riparian and agricultural habitats.

Culicidae (Mosquito family)

Mosquitoes undergo complete metamorphosis with four stages. The female mosquito lays her eggs on the surface of fresh or standing water; some species lay eggs on damp soil prone to inundation. Larvae hatch and live in the water, most using a siphon to breathe at the surface. Within one to two weeks, the larvae pupate. Pupae cannot feed, but can be active while floating on the water's surface. Adults emerge, usually in just a few days, and sit on the surface until they are dry and ready to fly. Adult females live two weeks to two months; adult males may only live a week.

Identifying characteristics for the family Culicidae include:

- Antennae with 6 or more segments (suborder Nematocera), plumose on males and short-haired on females.
- Proboscis long.
- Wings with scales on veins and along the margins.

Additional information:

- Females vector pathogens of major diseases including malaria (protozoan), yellow fever (virus), filariasis (nematode), dengue (virus), and certain types of encephalitis (virus).
- Larvae are aquatic, most feeding on algae, protozoans, and organic debris; a few species are predaceous on other mosquito larvae.
- Males and females feed on nectar and plant juices. Only females feed on blood.
- There are about 150 species of mosquitoes in North America.
- Yellow fever decimated the French army stationed in Haiti, contributing to Napoleon's decision to sell Louisiana to the United States in 1803 and assisting the Haitians in securing their independence in 1804.

Mansonia

Adults of Mansonia are generally large mosquitoes characterized by the presence of broad, asymmetrical scales on the wing veins. There is often a mixture of dark and pale scales that imparts a speckled appearance to the wings. Mansonia resemble some species of Culex, Aedini and Coquillettidia, but the tarsal claws are simple, the abdomen is truncate in females (distinctions from aedine genera), pulvilli are not evident (distinction from Culex) and postspiracular setae are present (distinction from Old World species of Coquillettidia). New World species of Coquillettidia possess postspiracular setae, but differ from Mansonia in having a conspicuous preapical white band on the anterior surface of the femora.

The larvae of Mansonia resemble those of Coquillettidia in having the spiracular apparatus and siphon distinctively modified for piercing plant tissues. They differ from Coquillettidia in having the distal part of the antenna fused with and much shorter than the basal part.

Mansonia titillans of subgenus Mansonia is an important pest in South and Central America and in the southern USA. It is known to transmit various arboviruses, including Venezuelan equine encephalitis. Some species of subgenus Mansonioides transmit several arboviruses, but they are mainly important as vectors of the helminths that cause Brugian filariasis in India and Southeast Asia. Mansonia uniformis, which is widely distributed from western Africa through southern Asia to Japan and the Australasian Region, is a vector of Wuchereria bancrofti in Western New Guinea. Mansonia and Coquillettidia larvae do not have to breathe at the water surface like most others. They have a sharp pointed siphon to pierce the roots or stems of aquatic plants for oxygen.

Phlebotominae (Sand Flies Family)

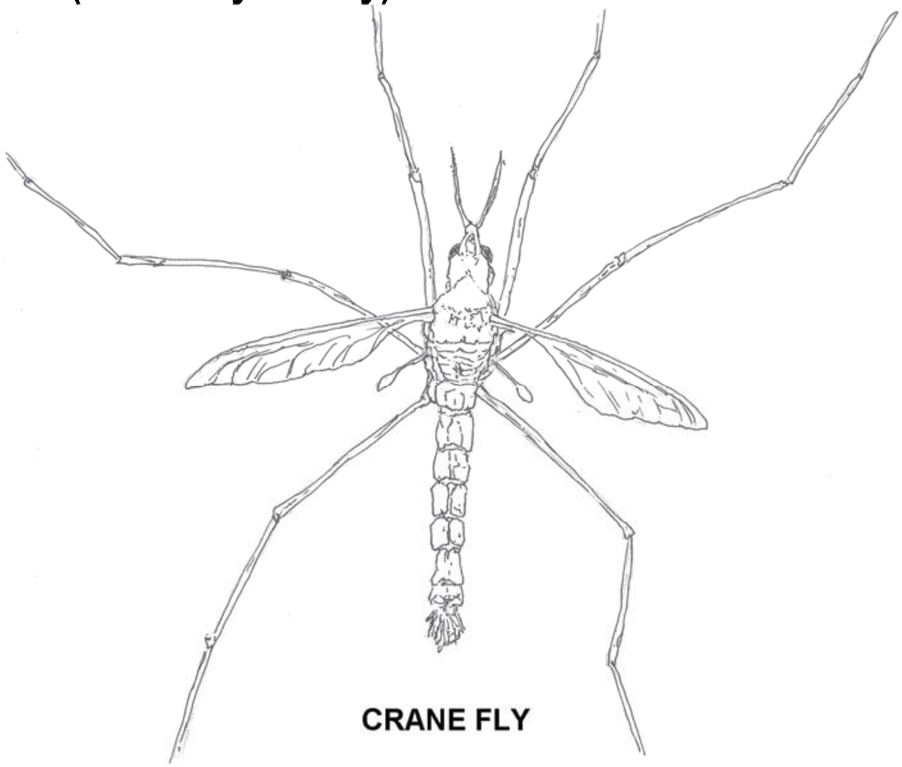
Members of the subfamily Phlebotominae are known outside of the United States by the name sand fly. This subfamily includes numerous genera of blood-feeding (hematophagous) flies, including the primary vectors of leishmaniasis, bartonellosis and pappataci fever. In the New World, leishmaniasis is spread by sand flies of the genus Lutzomyia, which are common inhabitants of caves, where they feed on bats. In the Old World, the disease is spread by sand flies of the genus Phlebotomus.

Female Sand Flies

Female sand flies suck blood from many warm-blooded animals because the blood helps them to make eggs. Only female sand flies bite, and use their mouthparts to create a pool of blood, which is then sucked up. They inject histamine to prevent blood clotting, similar to the feeding habits of a female mosquito. Females lay their eggs in humid soil rich in organic matter.

One blood meal can result in the creation of up to 100 eggs. Sand flies are small (with a body size of about 3mm in length), making them hard to detect. Their bite is sometimes not felt and leaves a small round, reddish bump that starts itching hours or days later. Use of insect repellent is recommended in areas where sand flies are present.

Tipulidae (Crane Fly Family)



A crane fly is an insect in the family Tipulidae. Adults are very slender, long-legged flies that may vary in length from 2–60 millimeters (0.079–2.4 in) (tropical species may exceed 100 millimeters or 3.9 inches).

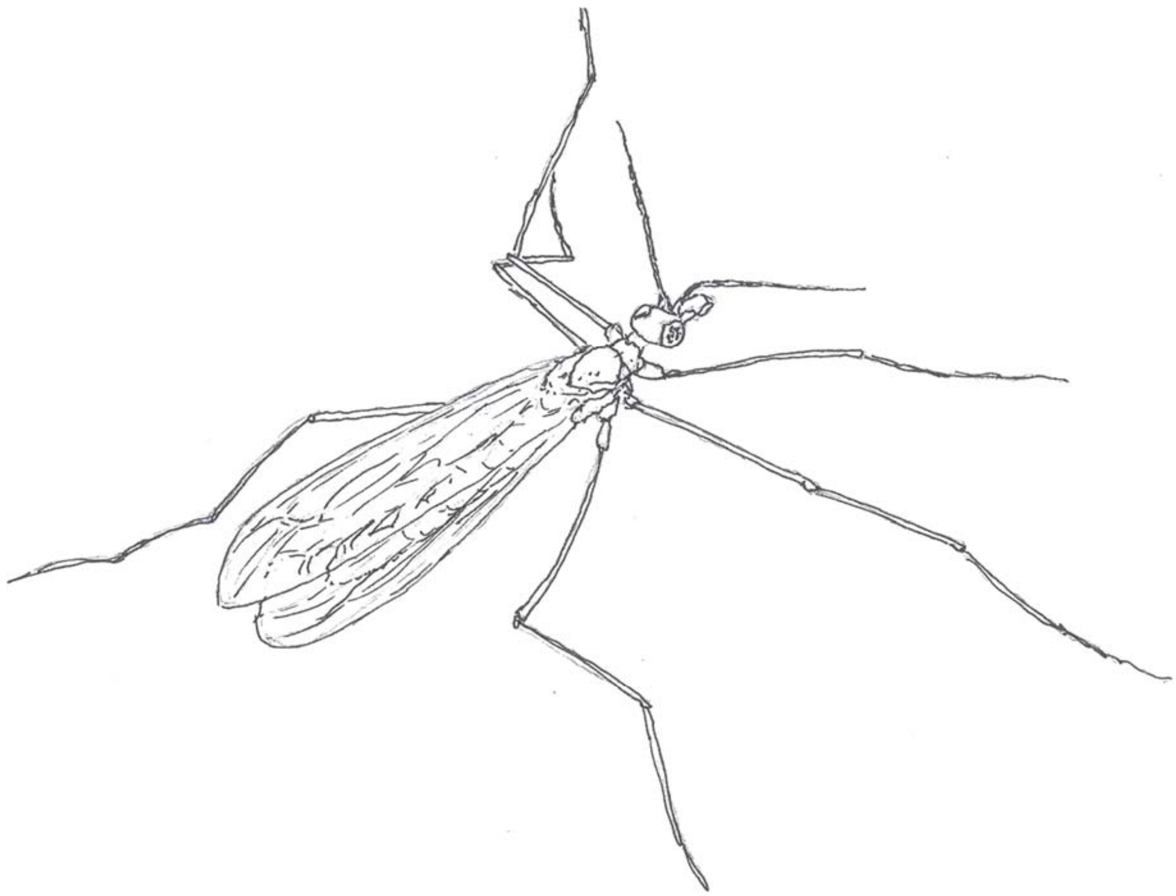
In the United Kingdom, Ireland and Newfoundland they are commonly referred to as daddy long-legs, but this name can also refer to two unrelated arthropods: members of the arachnid order Opiliones (especially in the United States and Canada) and the cellar spider Pholcidae (especially in Australia). The larva of the European Crane Fly is commonly known as a leatherjacket. These larvae can cause damage to lawns by feeding on the roots of grass plants. Numerous other common names have been applied to the crane fly, many of them more or less regional, including mosquito hawk, mosquito wolf, mosquito eater (or skeeter eater), gallinipper, and gollywhopper.

Largest Families of Diptera
At least 4256 species of crane flies have been described, most of them (75%) by the specialist Charles Paul Alexander. This makes Tipulidae one of the largest families of Diptera (although smaller than Limoniidae, one of the other extant families of crane flies). In appearance crane flies seem long and gangly, with very long legs, and a long slender abdomen. The wings are often held out when at rest, making the large halters easily visible. Unlike most flies, crane flies are weak and poor fliers with a tendency to "wobble" in unpredictable patterns during flight, and they can be caught without much effort. Crane flies vary in size, with temperate species ranging from 2 to 60 millimeters (0.079 to 2.4 in), while tropical species have been recorded at over 100 millimeters (3.9 in). The giant crane fly (Holorusia rubiginosa) of the western United States can reach 38 millimeters (1.5 in). Some Tipula species are 64 millimeters (2.5 in).

Many smaller species (known as bobbing gnats) are mosquito-sized, but they can be distinguished from mosquitoes by the V-shaped suture on the thorax, non-piercing mouthparts, and a lack of scales on the wing veins.

Females

Adult mouthparts may occur on the end of the crane fly's long face, which is sometimes called a snout or a short rostrum. Female abdomens contain eggs, and as a result appear swollen in comparison to those of males. The female abdomen also ends in a pointed ovipositor that may look somewhat like a stinger, but is in fact completely harmless. Larvae have a distinct head capsule, and their abdominal segments often have long fleshy projections surrounding the posterior spiracles (almost like tentacles). Little is known of the juvenile biology of many crane fly species. The larvae of less than 2% of the species have been described. Of those that have been described, many prefer moist environments, and some leatherjackets are aquatic.



WINTER CRANE FLY

Genera and important Mosquito species in the United States (Family Culicidae)

Only the most important species in each genus are listed by name.
Subfamily Anophelinae (anophelines)

Genus Anopheles 17 spp.
albimanus, bradleyi, crucians, franciscanus, freeborni, hermsi, psuedopunctipennis, punctipennis, quadrimaculatus spp. complex, walkeri.
Subfamily Culicinae (culicines)

Genus Aedes 4 spp.
aegypti, albopictus, cinereus, vexans

Genus Coquillettidia 1 spp.
perturbans

Genus Culex 29 spp. & subspecies
erraticus, nigripalpus, peccator, pipiens, pilosus, quinquefasciatus, restuans, salinarius, stigmatosoma, tarsalis

Genus Culiseta 8 spp.
incidens, inornata, melanura

Genus Deinocerites 3 spp.
cancer, mathesoni, pseudes

Genus Haemogogus 1 spp.

Genus Mansonia 2 spp.
dyari, titillans

Genus Ochlerotatus 77 spp.
abserratus, atlanticus, canadensis, cataphylla, communis, deserticola, dorsalis, excrucians, fitchii, hexadontus, increpitus, monticola, nigromaculis, punctor, sierrensis, sollicitans, spencerii, sticticus, stimulans, taeniorhynchus, triseriatus, trivittatus, varipalpus,

Genus Orthopodomyia 3 spp.
signifera, alba

Genus Psorophora 15 spp.
ciliata, columbiae, cyanescens, ferox, signipennis

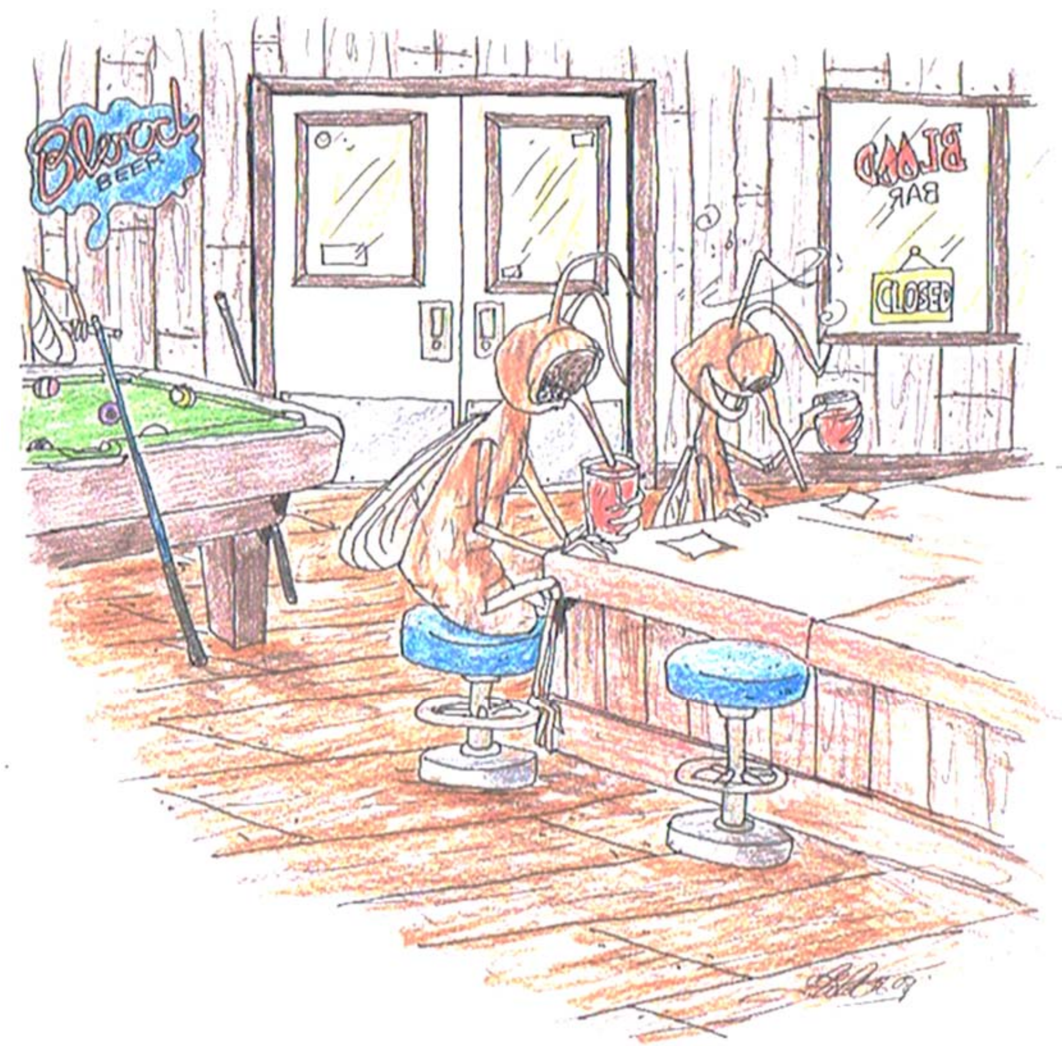
Genus Toxorhynchites 2 subspecies

Genus Uranotaenia 3 spp. & subspecies
Sappharina

Genus Wyeomyia 4 spp.
mitchellii

Here's the Bad News…

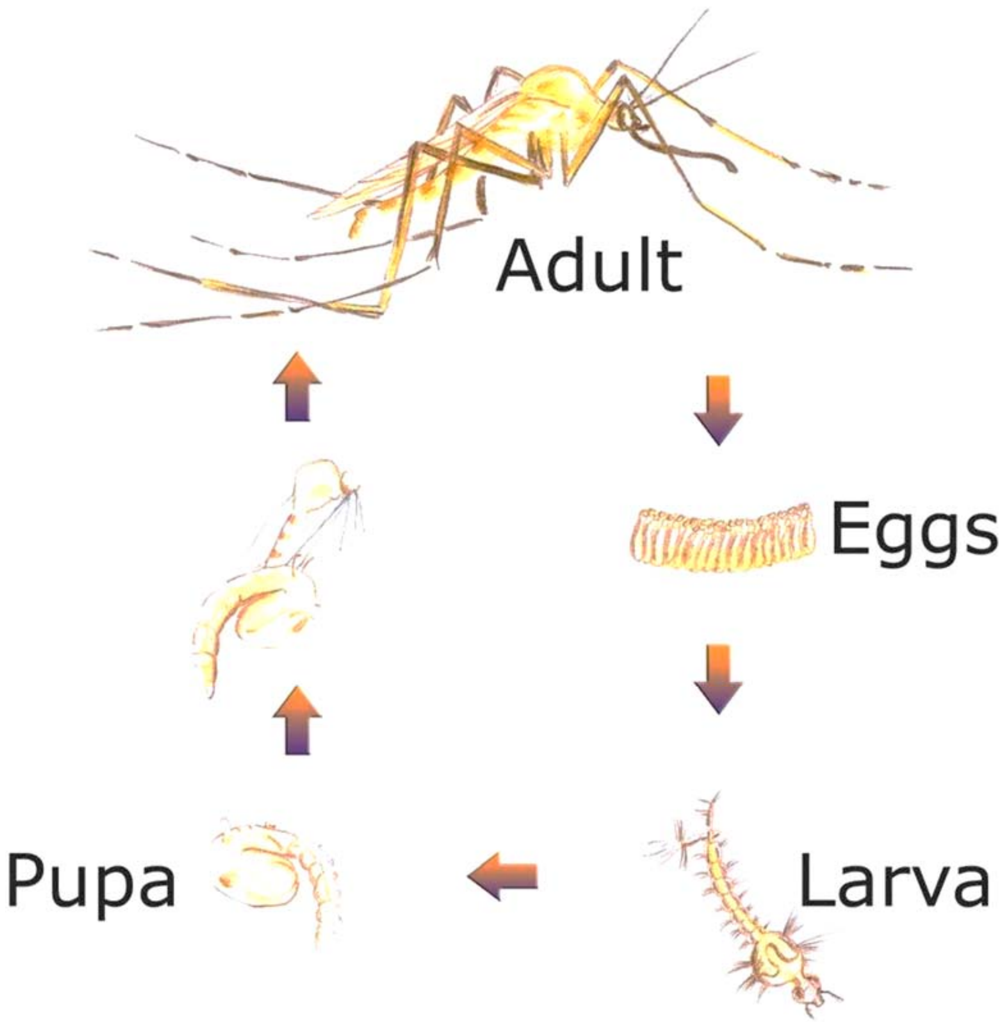
Recent documents found in terrorist's hideout have confirmed the worst possible scenario. Insects are a viable method of carrying diseases that can destroy mankind. Researchers have discovered that 25 species successfully carry viruses and toxins that can easily destroy mankind. A suitcase of these insects can potently wipe an entire city of all human life.



Mosquito Life Cycle

The type of standing water in which the mosquito chooses to lay her eggs depends upon the species. The presence of beneficial predators such as fish and dragonfly nymphs in permanent ponds, lakes, and streams usually keep these bodies of water relatively free of mosquito larvae.

However, portions of marshes, swamps, clogged ditches, and temporary pools and puddles are all prolific mosquito breeding sites. Other sites in which some species lay their eggs include tree holes and containers such as old tires, buckets, toys, potted plant trays, and saucers and plastic covers or tarpaulins.



Some of the most annoying and potentially dangerous mosquito species, such as the Asian tiger mosquito, come from these sites. The mosquito goes through four distinct stages during its life cycle:

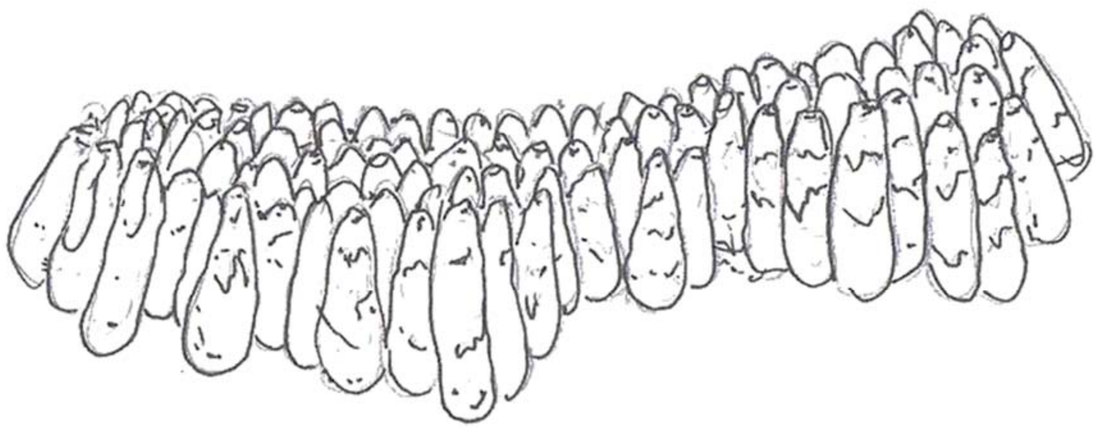
- **Egg:** hatches when exposed to water;
- **Larva** (plural. - larvae) **:** lives in the water; molts several times; most species surface to breathe air;
- **Pupa** (plural - pupae) **:** does not feed; stage just prior to emerging as adult;
- **Adult:** flies short time after emerging and after its body parts have hardened.

Wrigglers and Tumblers
The mosquitoes in the United States, all of which live in specific habitats, exhibit unique behaviors and bite different types of animals. Despite these differences, all mosquitoes share some common traits, such as a four-stage life cycle.

After the female mosquito obtains a blood meal (**male mosquitoes do not bite**), she lays her eggs directly on the surface of stagnant water, in a depression, or on the edge of a container where rainwater may collect and flood the eggs. The eggs hatch and a mosquito larva or "**wriggler**" emerges.

The larva lives in the water, feeds, and develops into the third stage of the life cycle called a pupa or "**tumbler**". The pupa also lives in the water, but no longer feeds.

Finally, the mosquito emerges from the pupal case and the water as a fully developed adult female, ready to bite.



MOSQUITO EGGS

Mosquitoes may overwinter as eggs, fertilized adult females or larvae. Eggs, larvae, and pupae must have water to develop. Some female mosquitoes lay their eggs directly on the water surface.

Others lay their eggs on substrates above the water line (flood pool mosquitoes); the eggs hatch upon flooding. In some cases, the eggs will remain viable for several years until further flooding occurs.

Mosquitoes belonging to the genus Culex lay their eggs in bunches or "*rafts*."

Each raft may contain up to 400 individual eggs. Larvae feed on bits of organic matter dispersed in the water, becoming full grown in about one week. The pupal stage lasts two to three days.

Female mosquitoes are ready to bite one to two days after adult emergence.

Male mosquitoes do not bite but feed on flower nectar or plant juices. Some mosquitoes have only one generation per year, whereas others may have four or more.

Adults may fly 5 to 10 miles, but usually rest in grass, shrubbery, or other foliage close to the water breeding area.

Mosquito Egg Classification
Mosquito eggs are generally cylindrical in shape, tapered at the top and rounded at the bottom. Each mosquito species prefers certain localities for depositing eggs. Some prefer very clean water, others slightly polluted water, while others thrive in extremely polluted water.

There are five distinct types of oviposition:
Single On Water: Anopheles and Toxorhynchites lay their eggs one at a time on the water surface. Single In Soil: most Aedes and Psorophora lay their eggs one at a time on a moist substrate, such as mud and decomposing leaf litter.

Single On Cavity Walls: Wyeomyia, Orthopodomyia, and certain Aedes deposit eggs in tree holes, water-holding plants, or artificial containers. The eggs are placed just above the waterline.

Rafts On Water: Most Culex, Culiseta, Coquillettidia, and Uranotaenia lay eggs in masses, called rafts or boats, on the water surface.

On Plants: Mansonia eggs are deposited on the underside, and sometimes on top, of the leaves of certain floating aquatic plants.

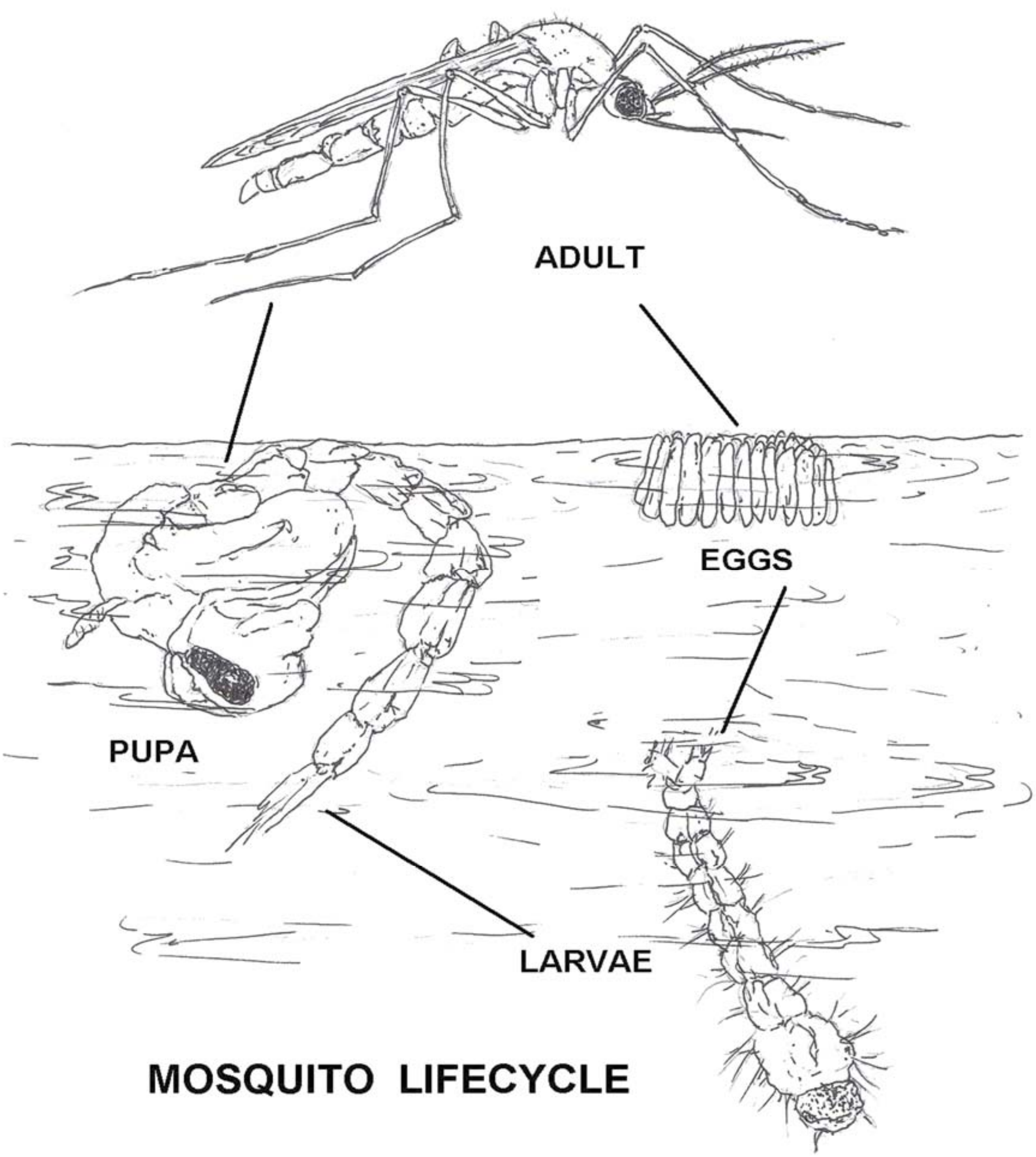
Weather
Mosquito development and population dynamics are closely tied to weather. When and how much rain is received, wind speed and direction, maximum and minimum temperatures, and the total amount of heat energy accumulated are all critical to mosquito development.

Water Source
The water (or lack thereof) in a habitat directly affects mosquito reproduction. All mosquitoes need standing water to complete their development. Factors such as when it first collects in sufficient quantities, how long it persists, quality, depth profile, vegetation and predator species (often lacking in artificial containers) and geographical distribution all affect mosquito development. Different species variously exploit nearly all combinations of these factors.

Mating most commonly occurs in twilight swarms within 2-3 days after females emerge. Most, but not all, females mate before they take blood. Both sexes feed frequently on plant nectar; females take blood in order to obtain protein for egg development. A few species are autogenous, meaning they do not need a blood meal to produce eggs. One Massachusetts species, the pitcher plant mosquito (Wy. smithii), never takes blood. Most females begin seeking hosts 2-4 days after emergence but some species (e.g., Cs. morsitans) may delay feeding for 2 weeks or more. Thus, the time period between adult emergence and the first egg laying (first gonotrophic cycle) is usually 7-10 days.

Subsequent host-feeding to egg-laying cycles in most temperate species require 4-6 days.

Species that transmit disease (vectors) must feed at least twice, once to acquire the infection, and once to transmit it, unless the infection is acquired transovarially (into the egg while in the ovary) from their mother. This means that females must normally survive for 12-14 days in order to be a vector. If the extrinsic incubation period of the pathogen/parasite in the mosquito is longer than the gonotrophic cycle, as is often the case, the survival time required for transmission is even longer. Most females do not survive beyond the first oviposition but a few individuals in all mosquito populations live a long time (i.e., several weeks). Exceptionally, overwintering adults live 5-7 months. Males generally survive for shorter periods than females and never overwinter.



Mosquito Habitats

Running Water: Few mosquito species in the U.S. breed in running waters, such as streams.

Larvae can be flushed out when stream volume increases, and to remain in the stream requires a large amount of energy. The tropical genus *Chagasia* and some *Anopheles* species are stream breeders. In addition, *Anopheles quadrimaculatus, Culex territans, and Uranotaenia sapphirina* have all been found in streams, although they prefer other habitats. Stream breeders will find vegetation along banks with which to anchor themselves or attempt to remain away from the main flow of the stream by seeking isolated eddies.

Transient Water: Transient water sources, such as flooded areas, snowpools, and ditches, are used as breeding grounds for mosquito species whose eggs can withstand desiccation, such as *Aedes* and *Psorophora*. Their life cycles require alternating periods of wet and dry. Other species, like an opportunistic *Culex,* might be able to pull off a single generation during an extended flooded period. Transient water generally shows water quality changes which result in various mosquito species using the same pool over a period of time.

Standing Water Mosquitoes

Permanent water group. Mosquito groups assigned to the permanent water group are Anopheles spp., Culex (Melanconium) spp., Cx. salinarius, Cx. territans, Coquillettidia spp. and Mansonia spp. As examples, the following permanent water habitat types and resident species are more or less typical of those found throughout the nation.

Freshwater Marsh
Mosquito species often found in freshwater marshes include An. walkeri, An. crucians, Psorophora columbiae, Cx. nigripalpus, Cx. salinarius, Cx. tarsalis, Cx. erraticus and Cx. peccator.

Lakes
Larvae may be found when many species of floating or emergent plants are present, but where vegetation occurs only in a narrow band along the lakeshore, larvae are confined to this littoral zone. Lake species include An. crucians, An. quadrimaculatus spp. complex, An. walkeri, Uranotaenia sappharina, Ur. lowii, Cx. salinarius, Cx. nigripalpus, Cx. erraticus, Cx. peccator, Cq. perturbans, Ma. dyari and Ma. titillans.

Ponds and Seepage Areas
There is no clear distinction between a pond and a lake except that ponds are generally smaller. Grassy woodland ponds or fluctuating ponds occupy shallow depressions and are filled by rainwater or surface run-off. They are usually of uniform depth, but the area they cover will vary, depending on rainfall. Sinkhole ponds are usually quite deep and may be covered with vegetation or free of all except marginal plants. Both types of ponds may contain larvae of An. crucians, An. quadrimaculatus spp. complex, Culiseta inornata, Cs. melanura, Cx. nigripalpus, Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, Cx. erraticus, Cx. peccator, Cx. pilosus, Cx. territans and Ochlerotatus canadensis. The seepage areas around hillsides and ponds or streams most often breed An. punctipennis, An. quadrimaculatus spp. complex, Oc. sticticus and Ps. ferox.

Springs

Mosquito breeding in springs is restricted to the quiet edges where vegetation affords cover for the larvae and there is little, if any, water movement. The only species recorded from are An. quadrimaculatus spp. complex and An. perplexens.

Swamps

Swamps differ from marshes principally in having dense cover from larger trees. The most common species of mosquito larvae found here are An. crucians, An. quadrimaculatus spp. complex, Cs. melanura, Oc. canadensis, Mansonia spp. and Cq. perturbans.

Transient Water Group

Mosquito groups assigned nationally to the transient water group are Cx. quinquefasciatus, Cx. tarsalis, Cx. restuans, Cs. inornata and Cs. melanura. As examples, the following specific habitat types and resident species are more or less typical of those found throughout the nation.

Salt or Brackish Water Ditches

The ditches adjacent to saltwater marshes contain many species of grasses and support a large mosquito fauna, including Oc. taeniorhynchus, Oc. sollicitans and An. bradleyi.

Borrow Pits and Canals

These man-made bodies of open water produce more mosquitoes as they silt-in and become overgrown with vegetation. They yield An. quadrimaculatus spp. complex, Cs. inornata, Ps. columbiae, Oc. canadensis, Cx. nigripa1pus, Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, An. albimanus, Cq. perturbans and Mansonia spp.

Freshwater Drainage Ditches

In pastures, at the bottom of road shoulders, in old fields and in lowland groves, freshwater ditches will often yield the following species of mosquito larvae: Ps. columbiae, Cx. nigripalpus, Cx. pilosus, Cx. erraticus, Cx. quinquefasciatus, An. crucians, An. walkeri, Oc. atlanticus, U. sappharina, U. lowii, Ps. ciliata and Oc. sollicitans.

Floodwater Mosquitoes

Floodwater Group
Mosquito groups assigned nationally to this floodwater group are Oc. sollicitans, Oc. taeniorhynchus, Oc. tormentor/atlanticus, Oc. thelcter, Oc. dorsalis, Oc. nigromaculis, Ae. vexans, Ps. ferox and Ps. columbiae. As examples, the following specific habitat types and resident species described are more or less typical of those found throughout the nation.

Mangrove Swamp
In the transitional zone from normal high tide to above all but the highest spring and storm tides, the heaviest mosquito breeding occurs. Plant and grass cover keep moisture conditions suitable for egg laying. Eggs are usually laid on sloping sides of potholes, ditches, sloughs, marsh edges or on the sides of small depressions, and sometimes over extensive, level, grass-covered areas. The eggs of some species require alternate flooding and drying before hatching. Species most often occurring are Oc. taeniorhynchus, Oc. sollicitans, An. atropos and Cx. nigripalpus.

Salt Marsh
Salt-tolerant herbaceous plants and typical salt grasses dominate this type of habitat. Extensive areas are often covered by a single plant species such as Distichlis spicata, Batis maritima or Salicornia perennis. It is in association with one of these plants or with black mangrove (Avicennia germinans) that breeding of Oc. taeniorhynchus and Oc. sollicitans occurs.

Rain and Floodwater Pools
These pools form the breeding place for a large number of species, especially Psorophora, Aedes and Ochlerotatus. The pools disappear in dry weather and support no true aquatic vegetation, though usually a layer of leaves and other detritus settles on the bottom. Mosquito species found in this habitat are Ps. johnstonii, Ps. pygnaea, Oc. atlanticus, Oc. bahamensis, Oc. dupreei, Oc. fulvus pallens, Oc. infirmatus, Oc. mitchellae, Oc. sticticus, Oc. tormentor, Ae. vexans, Ae. cinereus, Cx. atratus, Cx. pilosus and Cx. nigripalpus.

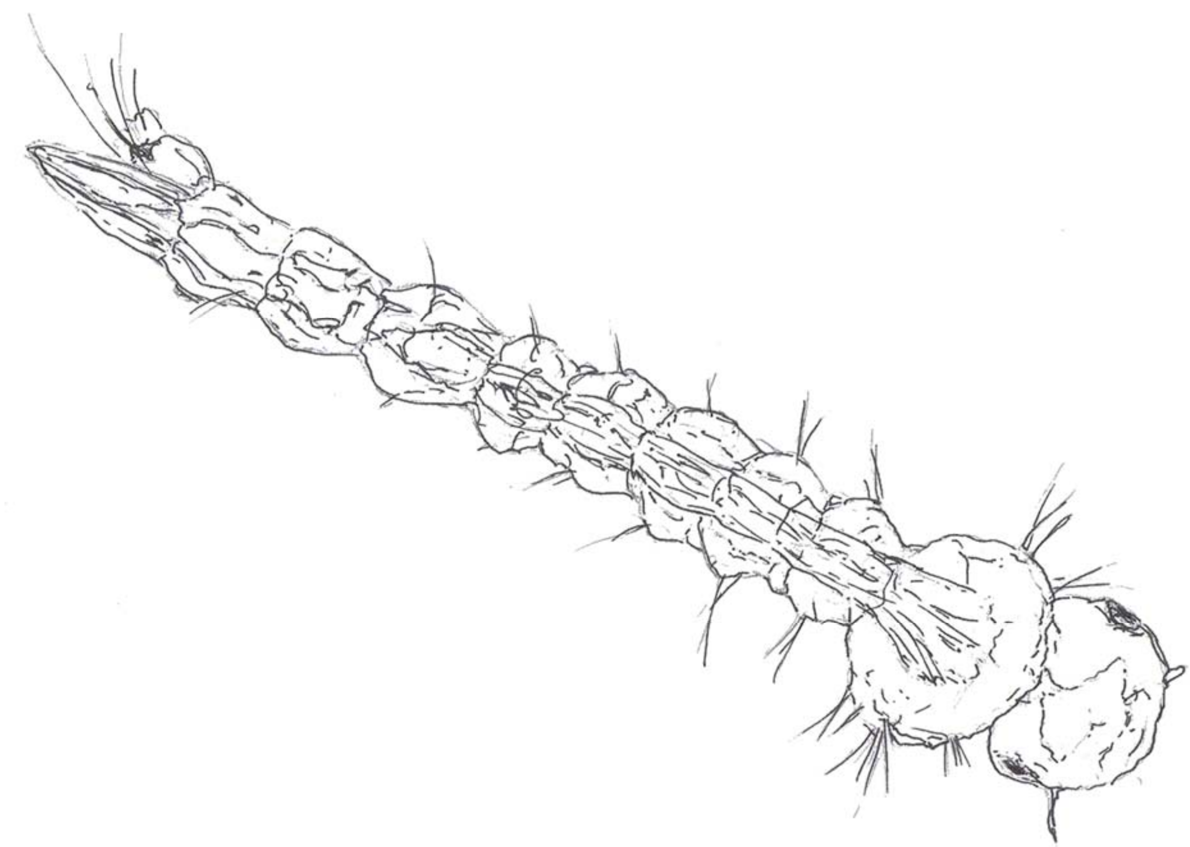
Artificial Container and Tree-hole Group
Mosquito groups assigned nationally to the artificial container and tree-hole group are Ae. aegypti, Oc. triseriatus, Oc. sierrensis, Ae. albopictus, Cx. quinquefasciatus, Toxorhynchites spp. and Orthopodomyia spp. As examples, the following specific habitat types and resident species described are more or less typical of those found throughout the nation.

Tree Holes
Tree holes or rot cavities support a rather extensive and unusual mosquito fauna, with many species breeding almost exclusively in this habitat. Resident species are An. barberi, Tx. rutilis rutilis, Tx. r. septentrionalis, Oc. triseriatus, Oc. hendersoni, Or. signifera, Or. alba, Oc. thibaulti and Ae. albopictus.

Crab Holes
Along the eastern coast the holes of the large land crab, Cardisonza guanhumi, serve as the larval habitat for Deinocerites cancer and Cx. opisthopus.

Artificial Containers
Several species breed in human-created situations around human dwellings. Tin cans, fish pools, cisterns, rain barrels, gutters and old tires, etc., containing water serve as excellent larval habitat. Species most often encountered are Ae. aegypti, Oc. triseriatus, Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, Cx. nigripalpus and Ae. albopictus. That many species are found in multiple habitat types and some in very specialized habitats illustrates the complexity of the problem faced by control agencies. While habitat association with many species is quite specific, others thrive in a variety of situations. Thus, the detection of adults of these latter species in routine surveys does not provide an immediate indication of the related breeding site(s).

Permanent water - These waters (also known as semi-permanent) are present for extended periods of time and support characteristic aquatic vegetation. Cattail, rushes and sedges are typical freshwater swamp vegetation. Genera associated with permanent water are *Anopheles, Culex, Culiseta, Coquillettidia,* and *Uranotaenia*. Eggs of these species are not desiccant-resistant and must be laid directly on the water. *Aedes* adults will oviposit near the edge of the swamp or within tussocks of vegetation, requiring later flooding to inundate the eggs for hatching. As with transient waters, there is a seasonal change in the vegetation, water quality, and mosquito species present. Permanent waters include:



MOSQUITO LARVAE

Mosquitoes and Aquatic Plants

More on this subject at the end of this section…

The three most important mosquito species that utilize aquatic plants as a primary habitat for egg deposition and larval development are Mansonia dyari, Mansonia titillans, and Coquillettidia perturbans.

If adult Mansonia species are discovered through routine surveillance monitoring, a thorough survey of the immediate area is conducted to locate fresh water sources containing water hyacinths and water lettuce. If a suspected fresh water source is found, a larval survey is conducted. Mansonia mosquitoes attach to the root structures of floating aquatic plants. If disturbed, the larvae will immediately release and fall to the bottom. When collecting these larvae, place a shallow pan under the floating vegetation. Care must be taken not to disturb the aquatic plants or surrounding area. Once in place, slowly lift the pan and plant out of the water. Clean water may be added to the pan to accurately view and count the mosquito larvae.

Asymmetrical Scales

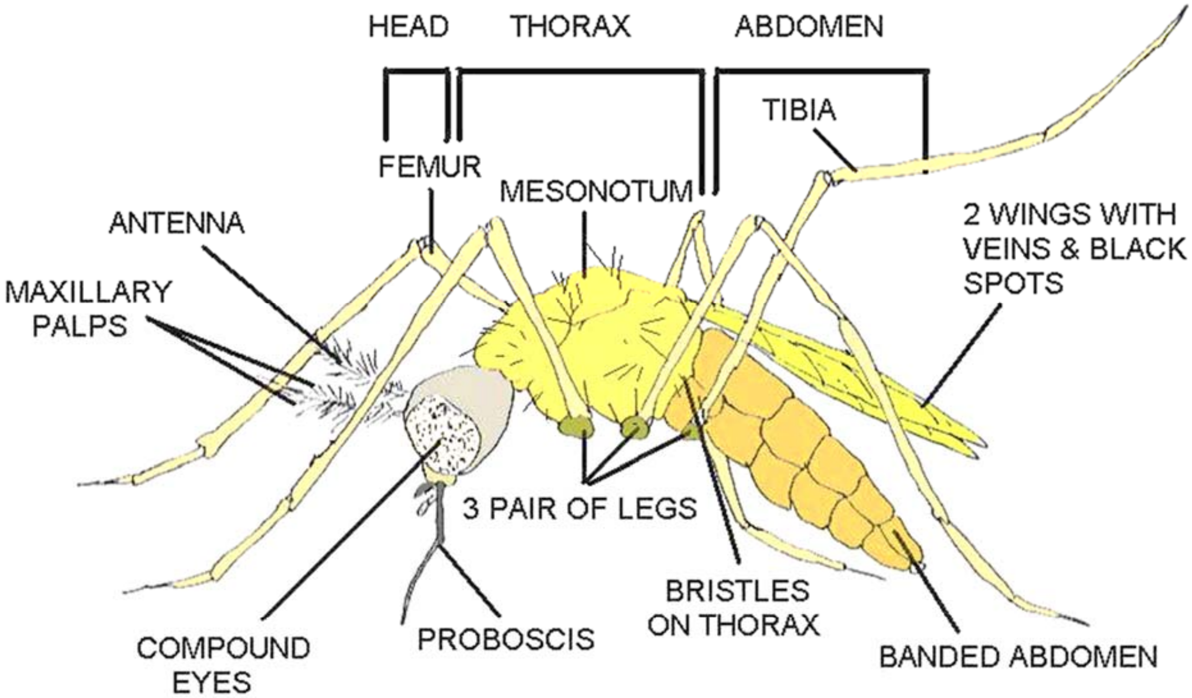
Adults of Mansonia are generally large mosquitoes characterized by the presence of broad, asymmetrical scales on the wing veins. There is often a mixture of dark and pale scales that imparts a speckled appearance to the wings. Mansonia resemble some species of Culex, Aedini and Coquillettidia, but the tarsal claws are simple, the abdomen is truncate in females (distinctions from aedine genera), pulvilli are not evident (distinction from Culex) and postspiracular setae are present (distinction from Old World species of Coquillettidia). New World species of Coquillettidia possess postspiracular setae, but differ from Mansonia in having a conspicuous preapical white band on the anterior surface of the femora. The larvae of Mansonia resemble those of Coquillettidia in having the spiracular apparatus and siphon distinctively modified for piercing plant tissues. They differ from Coquillettidia in having the distal part of the antenna fused with and much shorter than the basal part.

Cattail Mosquito

Coquillettidia perturbans can travel several miles. Therefore, a more widespread survey of fresh water sources containing cattails, sedges, aquatic grasses, or arrowhead may have to be done. The eggs and larvae of this mosquito are usually found in the detritus material at the base of the aquatic plants. A mosquito dipper or siphon can be used to collect the larvae. However, the water may have to be placed in a pan containing clean water for accurate viewing and counting. Because aquatic plants can, at times, produce heavily vegetated stands, the use of conventional mosquito management techniques may be ineffective.

Predator fish are usually not effective because of the dense vegetation. Monomolecular oils do not work because the immature mosquitoes are located below the water surface. Bti may be effective if the product is applied directly to the infested areas. This may be difficult and labor intensive if the aquatic vegetation is dense. Eradication or maintenance level control of the aquatic plants is the best method of managing these mosquitoes. The first step in identifying the breeding habitat was to determine where to check for breeding. Knowing that Cq. perturbans is always found associated with the roots and stems of emergent vegetation surrounding bogs, ponds, lakes, etc., all possible breeding sites were selected and inspected. These sites were selected with the use of topographic maps and aerial photographs of the area. Once all possible areas were identified, each of the areas was surveyed, both by ground and air, for the presence of emergent vegetation

Mosquito Identification Section
Alphabetical Common Name Order



ADULT FEMALE MOSQUITO
(Anopheles Mosquito)

Anopheles spp.

(Life; Kingdom: Metazoa; Phylum Arthopoda; Class: Hexapoda; Order: Diptera; Suborder: Nematocera; Family: Culicidae; Subfamily: Anophelinae)

Of the insects that serve as vectors for parasitic diseases, this genus is arguably the most important. Of the approximately 422 species of *Anopheles*, about two dozen serve as vectors for malaria (*Plasmodium* spp.) in humans. Mosquitoes also serve as the vector for canine heart worm (*Dirofilaria immitis*).

There are about 422 species of *Anopheles* worldwide, many of them sibling species that can only be identified using genetic techniques. Of these, about 70 are vectors of the protozoan *Plasmodium* that causes malaria, but only about 40 are important. Malaria infects 300-500 million people and kills 1.5-2.7 million people each year, making it by far the most serious of the diseases spread by insects.

Asian Mosquito AKA Asian Tiger Mosquito (*Aedes albopictus*)

Aedes albopictus

Aedes albopictus, an Asian mosquito, probably was introduced into Hawaii late in the last century. Until its discovery in Houston, Texas, in August 1985, this species was unknown in the New World. It is believed to be established in 866 counties in 26 states in the continental U.S.

The northernmost established infestation in the U.S. is Chicago, Illinois, although an infestation was found in Minnesota in 1997. In the Northeast, it has been reported from New Cumberland (York County), Pennsylvania and, in 1995, from Cumberland, Salem, and Monmouth counties in New Jersey. It has been found as far south as Cameron County, Texas, and Monroe County, Florida. In the West, it occurs in Del Rio (Val Verde County) and Lubbock (Lubbock County), Texas, and Omaha (Douglas County), Nebraska. Limited focal infestations in at least three northern states, Indiana, Minnesota, and Ohio, apparently have been eliminated through persistent control efforts by state and local agencies, perhaps coupled with severe winter temperatures. Nonetheless, other areas in Indiana and Ohio continue to be infested. During 1994, Georgia became the first state to document Ae. albopictus in all counties of the state and has since been joined by Florida, South Carolina, and Tennessee.

Aedes albopictus is a maintenance (occasionally epidemic) vector of dengue viruses in parts of Asia and is a competent vector of several other viruses under experimental conditions. Since the discovery of Ae. albopictus in the United States, five arboviruses (eastern equine encephalomyelitis, keystone, Tensaw, Cache Valley, and Potosi) have been isolated from this mosquito. Of these five viruses, only eastern equine encephalomyelitis and Cache Valley viruses are known to cause disease in humans.

Aedes albopictus was independently introduced into Brazil in 1986 and is now widespread in seven Brazilian states. In May, 1993, it was found to be established in the Dominican Republic, the first established infestation by this species of a Caribbean Island. In September, 1993, Ae. albopictus was also discovered in two border cities in Coahuila State, Mexico.

Subsequent studies indicate that areas of Tamaulipas and Nuevo Leon are also infested. In 1995, the Guatemalan Ministry of Health and Japanese entomologists in Guatemala reported finding Ae. albopictus at three sites in the Department of Izabal on the Atlantic seacoast. Also in 1995, infestations were reported from Cuba and Bolivia, but the current status of those infestations is uncertain. In 1996, infestations were reported from El Salvador and Colombia. In 1997, this species was reported from the Cayman Islands. In 1991, Ae. albopictus was found in Delta and Benue states in Nigeria. During 1994, additional infestations were found in Imo, Anambra, and Enugu states. In Europe, Ae. albopictus has been present in Albania since at least 1979.

More recently, infestations have been found in Italy (Genoa in 1990 and Padua in 1991) with a suggestion that the Padua introduction could have resulted from tire imports from the United States. Eighty-five percent of the imported tires came from a single source in Atlanta, Georgia; the remaining 15% came from the Netherlands. Ae. albopictus has rapidly become the most important pest mosquito species in areas of northern Italy and is now present in nine of Italy's 21 political regions, i.e., Veneto, Lombardy, Emilia Romagna, Liguria, Tuscany, Lazio, Piedmont, Campania, and Sardinia. Aedes albopictus is also expanding its distribution in the Pacific. Infestations were discovered in Palau in 1988 and in Yap in 1995. This mosquito was first discovered in Fiji on the island of Viti Levu in 1988, and has since spread to the next two largest islands in the group. Ae. albopictus has been found in port cities of both the north and south islands of New Zealand, and in Queensland and the Northern Territory of Australia, but apparently, has not become established.

Aedes albopictus is a potential vector of epidemic dengue. It is unclear what effect the presence of this species might have on transmission dynamics in the Americas. Ae. albopictus may also affect the disease potential for yellow fever in Brazil by bridging the ecological niche between jungle and urban transmission cycles. DVBID maintains a national database (under construction for web posting) on the distribution of Ae. albopictus, with particular emphasis on detecting its spread in areas in which La Crosse and eastern equine encephalitis viruses are enzootic. DVBID also studies the biology and vectorial capacity of Ae. albopictus and is the primary source of information about its distribution, vector competence, biology, and control in the Americas.

The Asian tiger mosquito, Aedes albopictus (Skuse), was first documented in the United States in Texas in 1985 (Sprenger and Wuithiranyagool 1986). A year later, the Asian tiger mosquito was found in Florida at a tire dump site near Jacksonville (O'Meara 1997). Since that time, this species has spread rapidly throughout the eastern states, including all of Florida's 67 counties (O'Meara 1997). The arrival of Aedes albopictus has been correlated with the decline in the abundance and distribution of the yellow fever mosquito, Aedes aegypti (Linnaeus). There are a number of possible explanations for the competitive exclusion of Ae. aegypti by Ae. albopictus. The decline is likely due to a combination of (a) sterility of offspring from interspecific matings; (b) reduced fitness of Ae. aegypti from parasites brought in with Ae. albopictus and; (c) superiority of Ae. albopictus in larval resource competition (Lounibos 2002). The distribution of Ae. aegypti currently is limited to the southeastern quadrant of the U.S., and small areas in New York and Arizona (Darsie and Ward 2005).

Aedes albopictus is a competent vector of many viruses including dengue fever (CDC 2001) and Eastern equine encephalitis virus (Mitchell et al. 1992). Its life cycle is closely associated with human habitat, and it breeds in containers with standing water, often tires or other containers. It is a daytime feeder and can be found in shady areas where it rests in shrubs near the ground (Koehler and Castner 1997). Aedes albopictus feeding peaks in the early morning and late afternoon; it is an opportunistic and aggressive biter with a wide host range including man, domestic and wild animals (Hawley 1988).

Bold Black Shiny Scales

Adult Aedes albopictus are easily recognized by the bold black shiny scales and distinct silver white scales on the palpus and tarsi (Hawley 1988). The scutum (back) is black with a distinguishing white stripe down the center beginning at the dorsal surface of the head and continuing along the thorax. It is a medium-sized mosquito (approximately 2.0 to 10.0 mm, males are on average 20% smaller than females). Differences in morphology between male and female include the antennae of the male are plumous and mouthparts are modified for nectar feeding. The abdominal tergites are covered in dark scales. Legs are black with white basal scales on each tarsal segment. The abdomen narrows into a point characteristic of the genus Aedes. Field identification is very easy because of these distinct features.

After entering the United States almost twenty years ago, Aedes albopictus has spread throughout much of the eastern states. The mosquito was most likely transported along highways and other major roadways in shipments of used tires imported from other countries for retreading. On January 1988, the U.S. Public Health Service required all used tires entering the U.S. from known endemic countries be dry, clean and treated with fumigants (Moore and Mitchell 1997). Surveillance for Ae. albopictus was initiated in 1986 and this species continues to be monitored by public health agencies (Morbidity and Mortality Weekly Report 1989).

Tolerance to Pesticides

Management of adult populations is more complicated than for other species due to insecticide tolerance to malathion, temephos and bediocarb (Morbidity and Mortality Weekly Report 1987). In many suburban areas, complaints to health departments are more frequently due to Ae. albopictus than in former years when Ae. aegypti was the most commonly reported nuisance mosquito (Morbidity and Mortality Weekly Report 1989). Source reduction is an effective way for people in the community to manage the populations of many mosquitoes, especially container breeding species such as the Asian tiger. The removal of mosquito breeding habitat can be an effective method for mosquito control (Dame and Fasulo 2003).

Eliminate any standing water on the property, change pet watering dishes, overflow dishes for potted plants, and bird bath water frequently. Do not allow water to accumulate in tires, flower pots, buckets, rain barrels, gutters etc. Use personal protection to avoid mosquito bites. Long sleeves and insect repellent such as DEET will reduce exposure to bites. The Asian tiger mosquito is a day biter with feeding peaks early morning and late afternoon, so by limiting outdoor activities during crepuscular periods (dawn and dusk) when mosquitoes are generally most active, bites can be avoided.

Life Cycle

Female tiger mosquitoes are the sex of most concern to humans because, as in the case for all mosquitoes, only females bite. The reason for the particular lust for blood by the female mosquitoes is the drive to reproduce. Blood is a rich source of protein which nourishes mosquito egg development and has since the age of the dinosaurs. Blood is not a food to sustain mosquito physiology aside from ovarian development. Carbohydrates from flower nectar fuel the daily activity of male and female mosquitoes.

Female tiger mosquitoes seek water-holding containers in which to lay their eggs. Any container from a tire casing to a tree hole is a possible breeding site, but this mosquito has preferences. Outdoor containers are greatly preferred over indoor containers and outdoor containers in the shade are preferred over those in full sunlight. Containers holding dark stained water high in organic content are preferred over containers holding clear, clean water.

Eggs are deposited along the sides of a container, just above the water surface. The rate of hatching success increases if the eggs remain unflooded for a few days after being laid and the eggs can remain viable for long periods before flooding, such as during prolonged droughts. The eggs are stimulated to hatch when the water level in the container rises and floods the eggs, provided the water temperature is above 60¤F. If colder water temperatures prevail, the eggs will not hatch, but can remain viable for long periods (overwinter) until warmer temperatures return. After hatching, mosquito larvae live in the water for one to several weeks, depending on water temperature and the amount of food present.

Immature mosquitoes go through four growth stages and molt their skins four times as their size increases. The last immature stage is known as the pupa. In the pupal stage, changes occur allowing the transformation from an aquatic larva to a terrestrial, free-flying adult mosquito. During the summer, the immature life stage typically lasts five to ten days.

Mating takes place shortly after adults emerge from breeding sites. Females mate only once in their lifetime. Sperm is stored in the females' bodies and they can lay fertile eggs several times during a life span. Two to three days after emergence, female mosquitoes take their first blood meal. Tiger mosquitoes rest, fly and bite close to the ground. They bite in the daytime, rarely at night. Early morning and late afternoon are peak biting times. Tiger mosquitoes are strongly attracted to bite humans, but will feed on cats, dogs and other mammals, as well as birds active on the ground. They will bite any exposed skin surface, but prefer to feed around the ankles and knees. They bite outdoors and indoors, but are usually found outside. On average, tiger mosquitoes ingest 2 - 6 milliliters of blood per bite.

Egg Laying

Female tiger mosquitoes lay 40 to 150 eggs after obtaining a blood meal. The cycle of blood feeding and egg laying will continue throughout the mosquito's life span. Egg laying occurs about once per week. The maximum number of eggs laid per lifetime by female tiger mosquitoes is about 300.

Adult tiger mosquitoes live from a few days to several weeks, largely depending on weather conditions. Hot, dry weather reduces life expectancy. Regardless of life span, adult tiger mosquitoes seldom move far from the containers in which they were born. Most adults will be found within a few hundred yards of the breeding container.

In many states, tiger mosquito eggs are present year round. Larvae are present from April through October. Adult tiger mosquitoes are found May through October. The period of peak population is June through September.

Tiger mosquitoes are known to transmit the causative agent of dog heartworm disease. In New Orleans, the tiger mosquito is a principal vector of dog heartworm. In Polk County, Florida, field populations of tiger mosquitoes were found to carry eastern equine encephalitis virus in 1991. In Asia, this species is a vector of dengue fever and Japanese encephalitis. Laboratory studies have found the tiger mosquito to be an efficient vector of many viral disease agents including yellow fever, West Nile virus, St. Louis encephalitis and LaCrosse encephalitis.

Monitoring Population (Surveillance)
Adult tiger mosquitoes are not readily attracted to standard light traps which are used for determining the population level of most Maryland mosquito species. Traps using carbon dioxide as an attractant are useful for monitoring population trends of adult tigers. The most efficient and widely used surveillance technique in Maryland is the landing rate count. Landing rate counts are taken by inspectors using themselves as "bait" to attract female tiger mosquitoes. As they land on the inspector to bite, mosquitoes are identified, killed and tallied. Counts are taken for two to five minutes, during which the inspector tallies the total number of mosquitoes landing. Inspectors wear dark colored clothing and, of course, are not allowed to use mosquito repellent. Trap collections and landing rate counts are taken between the hours of sunrise to sunset when tiger mosquitoes are most active.

Larval surveillance is carried out by visual inspection of containers and by dipping. The larvae are easily disturbed by vibration or shadows passing over their surface, and either event will send the larvae to the bottom of the container where they are difficult to find.

Tiger Mosquito Control
Control of tiger mosquitoes by conventional methods in the United States has proven to be difficult. The impact of several predators and parasites as biological control agents of larvae has been investigated. In general, these agents have been found to play a small role in regulating the number of mosquitoes but not a significant impact.

The most promising predators of tiger mosquito larvae are mosquito fish (Gambusia spp.) and cannibal mosquitoes (Toxorhynchitus spp.). Fish are very effective when stocked in cisterns, water barrels and ornamental ponds, but many of the breeding sites of tiger mosquitoes are so small and cryptic as to make the use of fish of limited value. Cannibal mosquitoes are predaceous as larvae on a wide range of aquatic organisms, including mosquito larvae. These mosquitoes are also container breeders and would seem to be an ideal candidate species as a biocontrol agent of tiger mosquitoes.

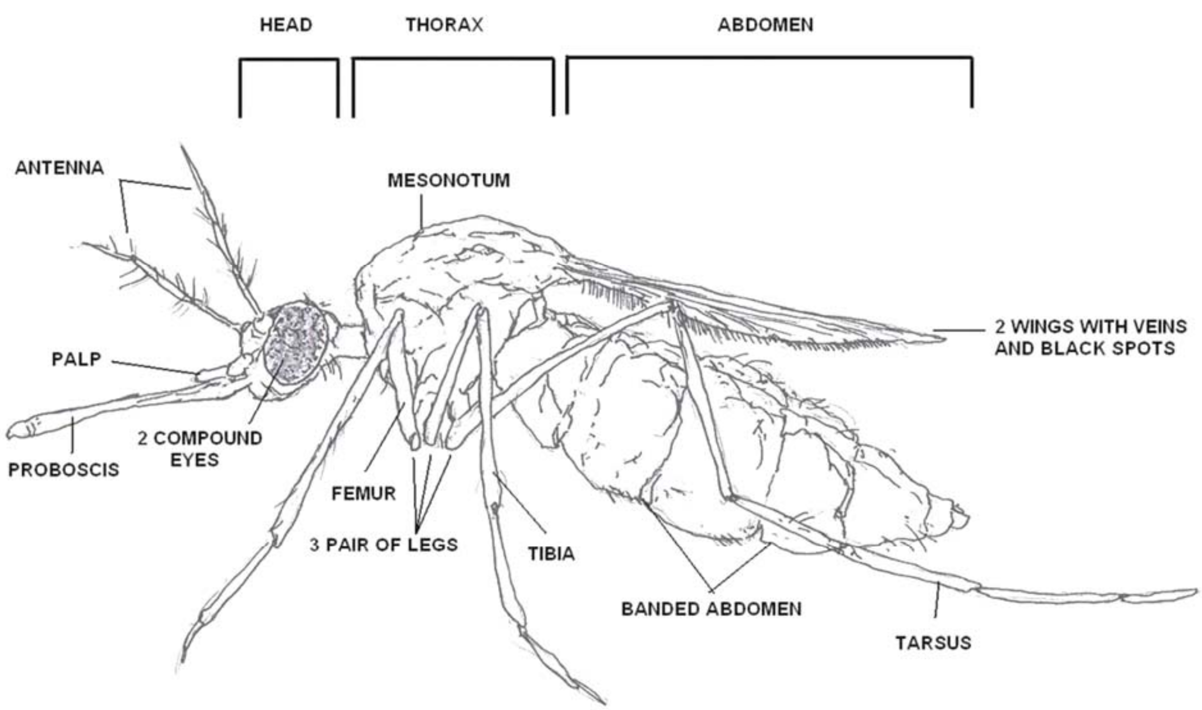
Tiger mosquito larvae are susceptible to the toxic spores produced by the bacteria Bacillus thuringiensis israelensis (Bti). The insect juvenile hormone mimic methoprene does not kill tiger mosquito larvae, but prevents maturation to adult mosquitoes. The problem of controlling tiger mosquitoes with Bti and methoprene is how to deliver the products to the breeding sites. Due to the large number and cryptic location of breeding sites, application of larvicides is labor intensive and beyond the resources of public agency mosquito control programs.

Insecticides
Control of adult tiger mosquitoes by various insecticides can be effective, providing temporary relief from biting annoyance and can reduce the risk of disease transmission. Spraying is most effective when done during early evening (one hour before to two hours after sunset) and early morning (two hours before to one hour after sunrise). Those mosquitoes killed by spraying can be replaced by newly emerged adults because of the rapid breeding cycle of the tiger mosquito.

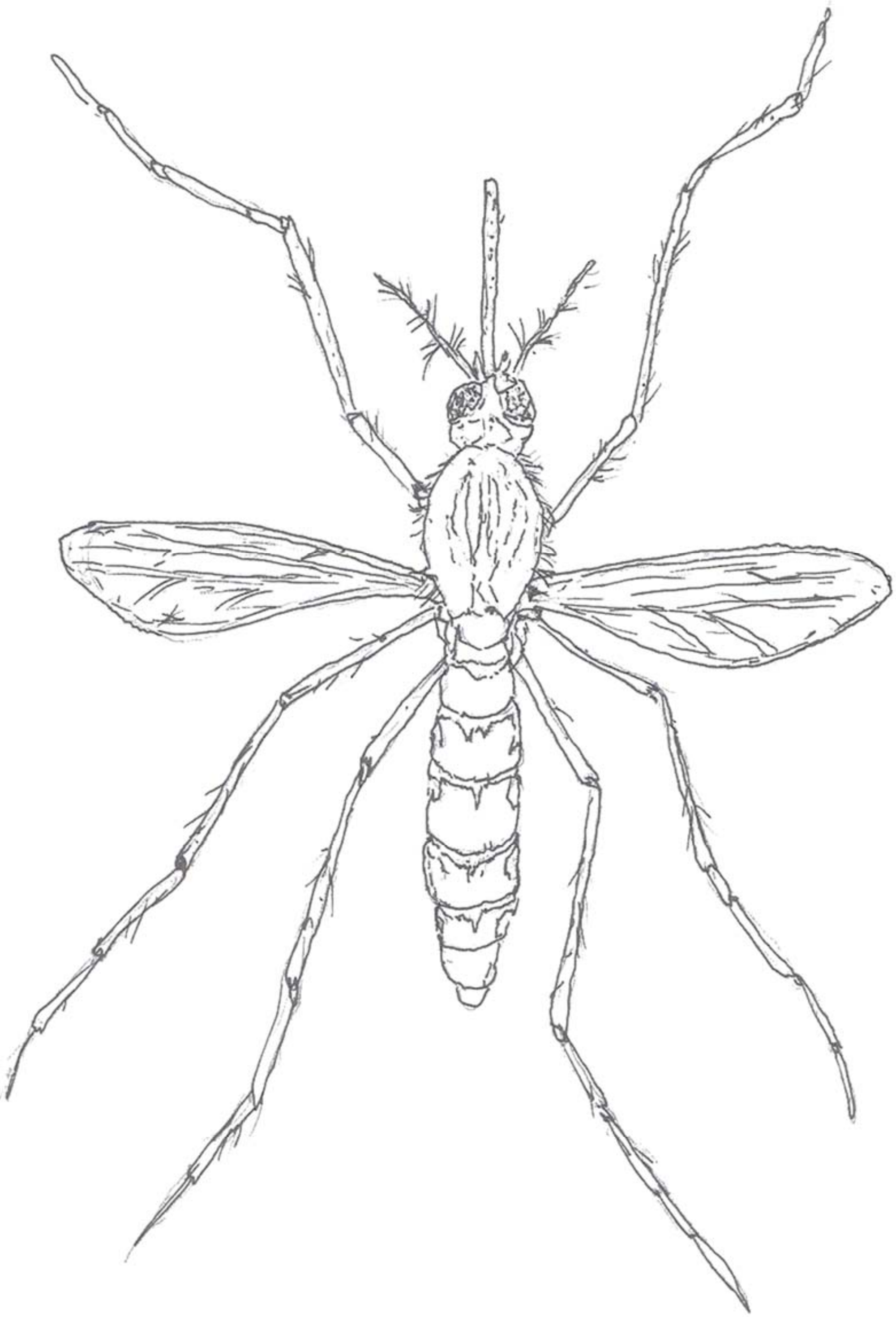
In communities infested by moderate to high populations of tiger mosquitoes, adult mosquito control spraying may be necessary once per week, or more frequently, from June through September.

The most effective method of controlling tiger mosquitoes is reducing or eliminating the containers which are the source of the problem. Draining or removal of water holding containers, even on a localized basis, will produce remarkable long-term reductions in mosquito annoyance. The list of breeding sites is extensive and includes any water holding containers, but the primary sites in residential areas include clogged rain gutters, tires, buckets, cans, bottles, boats, flower pots, bird baths, outdoor statuary, ornamental pools, plastic or canvas tarpaulins, children's toys, rain barrels, and pet food and water dishes.

The elimination of the breeding containers for tiger mosquitoes is largely the responsibility of the individual to conduct thorough and repeated efforts to remove or drain all such containers on his/her property. On an individual basis, this is not a large task. The original cleanup of containers on a residential area should take no more than a few hours and periodic maintenance to keep each yard free of breeding containers will require a minimal time investment by individual residents.



ANOPHELES MOSQUITO



AEDES AEGYPTI

Cattail Mosquito (Coquillettidia perturbans)
AKA Salt and Pepper Mosquito

Coquillettidia perturbans can travel several miles. Therefore, a more widespread survey of fresh water sources containing cattails, sedges, aquatic grasses, or arrowhead may have to be done. The eggs and larvae of this mosquito are usually found in the detritus material at the base of the aquatic plants. A mosquito dipper or siphon can be used to collect the larvae. However, the water may have to be placed in a pan containing clean water for accurate viewing and counting.

Because aquatic plants can, at times, produce heavily vegetated stands, the use of conventional mosquito management techniques may be ineffective. Predator fish are usually not effective because of the dense vegetation. Monomolecular oils do not work because the immature mosquitoes are located below the water surface. Bti may be effective if the product is applied directly to the infested areas. This may be difficult and labor intensive if the aquatic vegetation is dense. Eradication or maintenance level control of the aquatic plants is the best method of managing these mosquitoes.

This species is rather large, speckled brown and pale colored and has characteristic pale bands at the lower thirds of the hind leg segments. They are aggressive biters and readily enter homes. Larvae are unusually slow to develop and spend the entire development through pupa underwater. They are found attached to stalks of vegetation and do not need to rise to the surface to breath.

Larval habitat: Cattails marshes and in thick growth at edges of ponds, lakes and ditches
Biting time: Day and dusk
Preferred host: Mammals, including humans
Flight range: 1-5 miles from breeding site

Proboscis: dark, sprinkled with white scales basally and with broad median ring of pale scales.

Palpi: about one fifth as long as proboscis, dark-scaled, lightly speckled with pale scales.

Head: Occiput with pale-golden lanceolate scales and dark erect forked scales, a few pale forked scales on anterior part. Tori light brown on outer surface, darker and with a patch of grayish-white scales on inner surface.

Thorax: Integument of scutum mottled dark brown and black; scutum clothed with dark brown lanceolate scales intermixed with pale-golden lanceolate scales; The golden scales are more numerous anteriorly, laterally and on the pre-scutellar space. Scutellum with pale-golden scales and brown setae on the lobes. Pleura with patches of grayish-white scales. Spiracular and post-spiracular bristles absent.

Abdomen: First tergite dark-scaled; remaining tergites dark-scaled, with white or pale-yellow basolateral patches and occasionally with narrow basal segmental bands of pale scales. Venter with intermixed dark and pale scales, the pale scales more numerous on the basal part of the sternites. 8th segment bluntly rounded. 8th tergite without short stout spines.

Legs: Femora dark, speckled with pale scales, the apices almost entirely dark-scaled. Hind femur with narrow sub-apical, more or less distinct ring of pale scales. Posterior surface of middle and hind femora predominantly pale-scaled except near apices. Front and middle tibiae dark-scaled, speckled with white, narrowly ringed with white scales at apices; hind tibia dark-scaled, speckled with white, ringed with white scales at outer third and at apex. 1st tarsal segment of all legs with narrow white ring basally and a broader white ring a little beyond middle; remaining tarsal segments each with basal half white apical half dark.

Wings: Length about 4.0 mm, scales broad, mixed dark and white.

Egg Rafts
The eggs are laid on the surface of water in areas of heavy emergent vegetation, after hatching the larvae attach themselves with their modified siphon to the roots or submerged stems of plants where they remain throughout development until they are ready to emerge as adults. They overwinter as larvae ...adults emerge in Spring and Summer. They bite during night but will bite in shade if disturbed. They are strong fliers (1 to 5 miles) and are important pest in areas near shallow with emerged aquatic vegetation. They are attracted to light traps. They can transmit Eastern Equine Encephalitis.

Breeding Habitat
The first step in identifying the breeding habitat was to determine where to check for breeding. Knowing that Cq. perturbans is always found associated with the roots and stems of emergent vegetation surrounding bogs, ponds, lakes, etc., all possible breeding sites were selected and inspected. These sites were selected with the use of topographic maps and aerial photographs of the area. Once all possible areas were identified, each of the areas was surveyed, both by ground and air, for the presence of emergent vegetation.

Common Malaria Mosquito (*Anopheles quadrimaculatus*)

Anopheles sp.
Another example of *Anopheles* sp.

Anopheles quadrimaculatus Say is historically the most important vector of malaria in the eastern United States. Malaria was a serious plague in the United States for centuries until its final eradication in the 1950s (Rutledge et al. 2005). Despite the ostensible eradication, there are occasional cases of autochthonous (local) transmission in the U.S. vectored by An. quadrimaculatus in the east and Anopheles freeborni in the west (CDC 2005).

In addition to being a vector An. quadrimaculatus can also be a pest species (O'Malley 1992). This species has recently been recognized as a complex of five sibling species (Reinert et al. 1997) and is commonly referred to as An. quadrimaculatus (sensu lato) when in a collection or identified in the field. The preferred hosts are large mammals including humans.

Distribution

Anopheles quadrimaculatus mosquitoes are primarily seen in eastern North America. They are found in the eastern United States, the southern range of Canada, and parts of Mexico south to Vera Cruz. The greatest abundance occurs in the southeastern U.S. (Carpenter et al. 1946, Carpenter and LaCasse 1955).

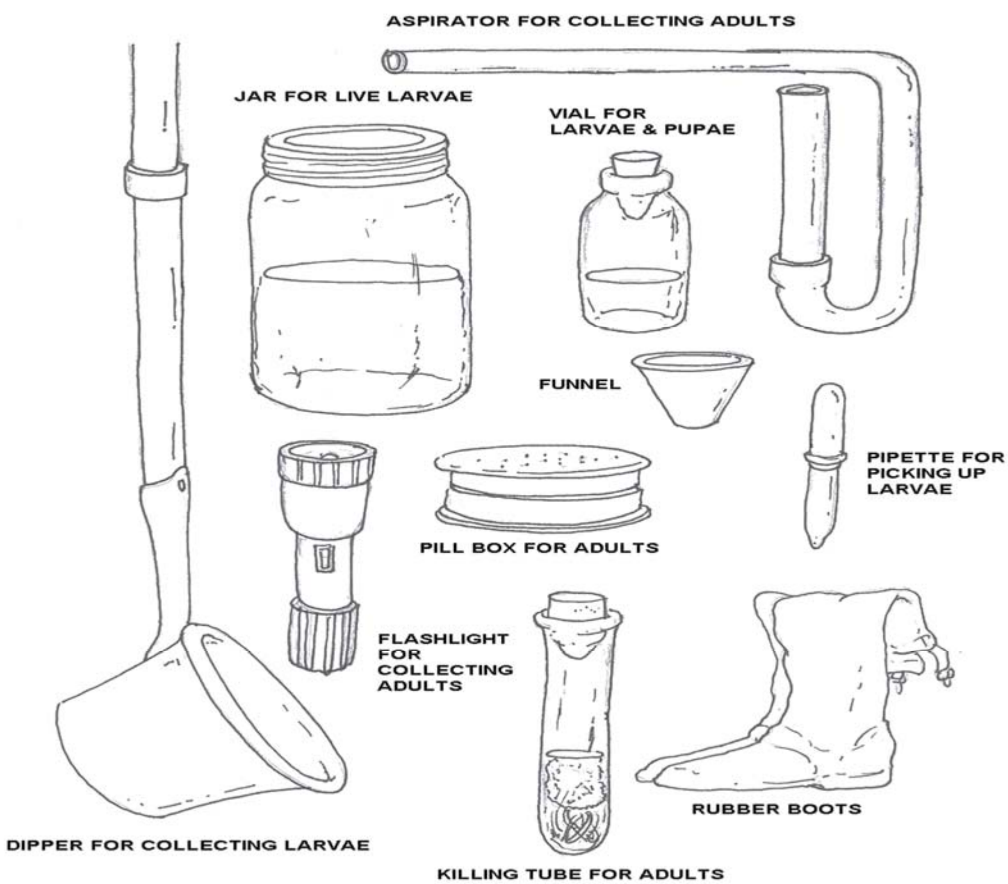
Mosquito Egg Classification
Mosquito eggs are generally cylindrical in shape, tapered at the top and rounded at the bottom. Each mosquito species prefers certain localities for depositing eggs. Some prefer very clean water, others slightly polluted water, while others thrive in extremely polluted water.

There are five distinct types of oviposition:
Single On Water: Anopheles and Toxorhynchites lay their eggs one at a time on the water surface.
Single In Soil: most Aedes and Psorophora lay their eggs one at a time on a moist substrate, such as mud and decomposing leaf litter.

Single On Cavity Walls: Wyeomyia, Orthopodomyia, and certain Aedes deposit eggs in tree holes, water-holding plants, or artificial containers. The eggs are placed just above the waterline.

Rafts On Water: Most Culex, Culiseta, Coquillettidia, and Uranotaenia lay eggs in masses, called rafts or boats, on the water surface.

On Plants: Mansonia eggs are deposited on the underside, and sometimes on top, of the leaves of certain floating aquatic plants.



MOSQUITO SAMPLING EQUIPMENT

Eastern Treehole Mosquito (*Aedes triseriatus*)

Aedes triseriatus is a treehole mosquito, breeding in the wild in holes left in trees when a branch breaks off and/or insect damage causes a part of the tree to rot out. Within the shaded forest it is a ready biter but it does not venture far from its breeding areas. Because it's larval habitat is widely dispersed (and often well above the height that a person could reasonably be expected to reach), larval control is not possible. Fortunately, because it stays within the woods, control targeting Ae. triseriatus is rarely necessary. Adult mosquitoes are small, fragile insects with slender bodies; one pair of narrow wings (tiny scales are attached to wing veins); and three pairs of long, slender legs. They vary in length from 3/16 to 1/2 inch. Mosquitoes have an elongate "beak" or piercing proboscis. Eggs are elongate, usually about 1/40 inch long, and dark brown to black near hatching. Larvae or "wigglers" are filter feeders that move with an S-shaped motion. Larvae undergo four growth stages called instars before they molt into the pupa or "tumbler" stage. Pupae are comma-shaped and nonfeeding and appear to tumble through the water when disturbed.

Overwinter

Aedes triseriatus overwinter as eggs in the larval habitat; hatching occurs in early spring and development to the adult stage takes about 3 months. The first biting adults appear in late June. Larval populations are often crowded and asynchronous so some emergence continues until early August. A second generation of larvae has been observed, especially in tires, where water is usually warmer and development is faster. However, it is doubtful that many adults from this generation are successful at this latitude. This mammal-feeding, diurnal species does not normally disperse far from its sylvan larval habitats. Biting adults are particularly active in the late afternoon, pre-twilight period (i.e., 4-7 PM).

Tire Removal

If Ae. triseriatus stayed in the trees, it would be a minor pest, but it has become well adapted to breeding in tires, particularly where they are shaded. As a result, Ae. triseriatus can be a locally important pest wherever rimless tires are stored.

Tire removal, and the prevention of illegal tire dumping along wooded roads, is an important part of mosquito control.

Vexans Mosquito

Aedes vexans. Aedes vexans is the most ubiquitous floodwater mosquito in North America and is the predominant summer re-flood mosquito. Aedes vexans is found in lake and river flood plains, shrub swamps, flooded meadows, and shallow grassy depressions associated with open habitats such as roadside ditches, pastures, golf courses and athletic fields. It will also breed in woodland pools and shallow cattail marshes, such as those that develop in some retention ponds. The first Ae. vexans are normally not on the wing before mid-June. Populations of Ae. vexans are unpredictable because they depend entirely on the frequency and spacing of major rains. Rainfall of 1 inch many produce some Ae. vexans but it usually requires 3” of rain within a short period of time (several days) to produce a large brood.

Larval Broods

Larval broods of Ae. vexans have been observed as late as mid-September. It is not always clear whether such late season broods result from the delayed and staggered hatching of eggs that are a year or more old or from the hatching of non-diapausing eggs laid earlier the same season. Brust and Costello (1967) and Horsfall et al (1973) have shown that many species such as Ae. vexans lay some eggs that will hatch without cold conditioning. Sequential hatching of eggs is also well documented in five reflood Aedes species (i.e., canadensis, cinereus, sticticus, trivittatus, and vexans). Larval development is rapid, 4-6 days, and the pupal stage lasts for about 2 days. Hence, the window for effective larval/pupal control is narrow. Moreover, a large number of scattered pools all need to be treated within the same brief time span following major rains. Control efforts suffer from the same difficulties as described for Ae. canadensis, as Ae. vexans will often breed in mid-summer in the same pools used by Ae. canadensis in the spring.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas. By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas.

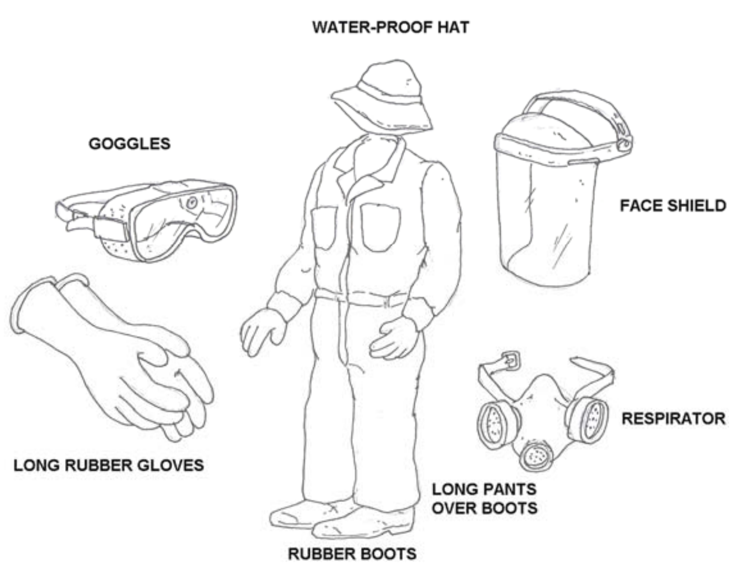
Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas. The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment.

Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public. Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Mosquito Repellents
The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

PESTICIDE PROTECTIVE EQUIPMENT



Foul Water Mosquito *(Culex stigmatosoma)*

Culex stigmatosoma is known as the Banded Foul Water Mosquito due to its association with polluted water and can be found in most California counties. The Banded Foul Water Mosquito is a dark bodied, medium-sized mosquito with a prominent white band on its proboscis (beak) and white bands on the tarsi (feet). It is further characterized by black scales which form "o" spots on the underside of the blunt-tipped abdomen. This mosquito most closely resembles Culex tarsalis but lacks the white stripe on the hind legs.

Adult Daily Activity
These mosquitoes may live for two or three weeks in the summer, but under cooler conditions the females may live for several months. In areas of moderate climate, adults and larvae may be found in every month of the year, but in areas with cold winters this species usually passes the winter as hibernating females in protected natural or artificial shelters such as cellars, outbuildings, wood piles, caves, culverts, etc. Mating may take place in conjunction with the male swarms.

Adult Flight Range
This species is capable of traveling 1-2 miles to seek a host, but is most commonly found near its aquatic habitat. The maximum recorded flight range is less than ten miles.

Adult Feeding
Female foul water mosquitoes seem to prefer feeding on birds, but on occasion will feed on livestock and humans. Males feed on nectar and plant juices. Females may also feed on plant juices, but usually must have a blood meal in order to develop their eggs. Nighttime is the peak feeding time for females of this species.

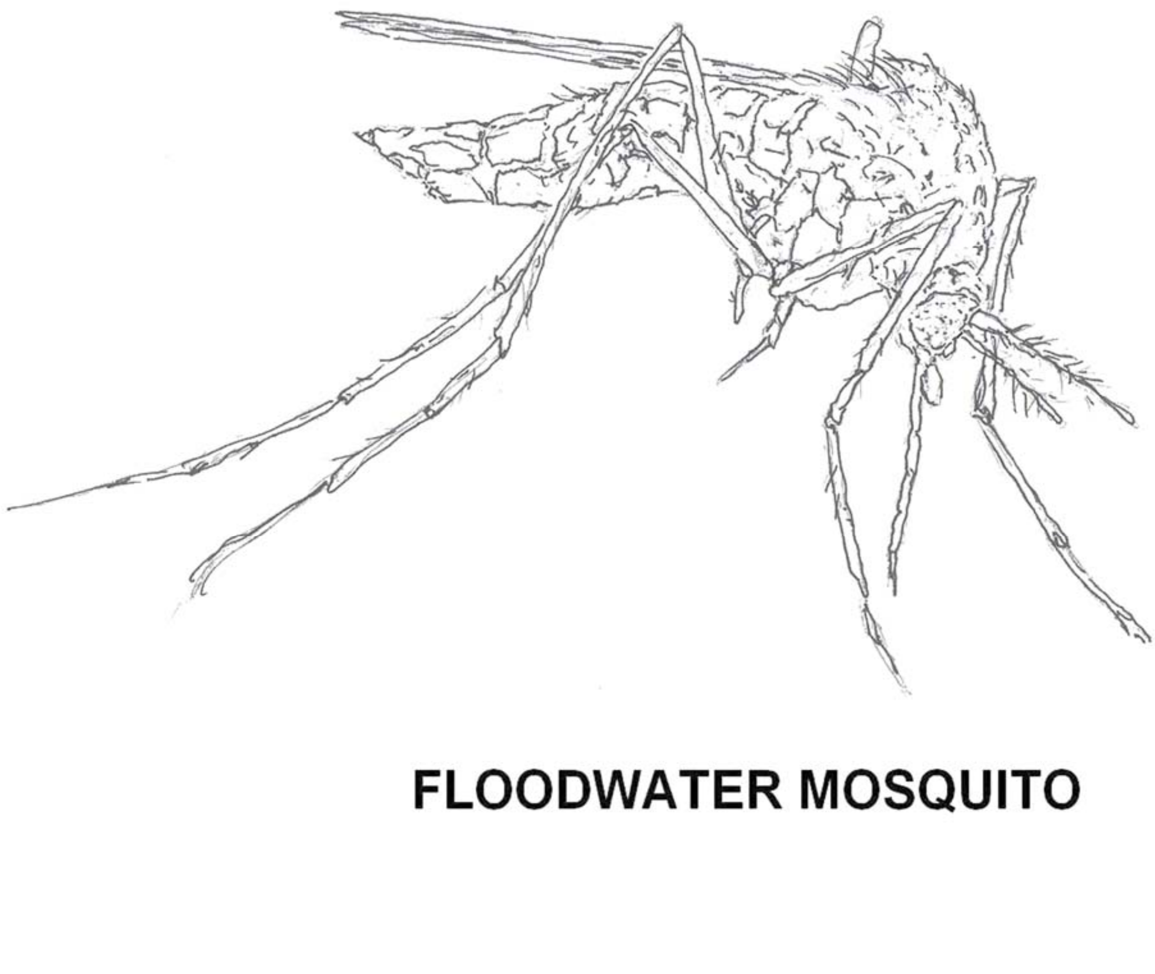
Eggs and Larvae
An adult female lays about 150-200 eggs in clusters called rafts, which float on the surface of the water until they hatch in about one to two days. The female usually prefers laying eggs in standing, polluted water such as sewage, street drainage, industrial wastes, dairy ponds, log ponds and backyard sources such as unused swimming pools, fouled ornamental ponds, cooler drain-water, and water in containers. A wide variety of other water sources may also be infested with the aquatic stages of this common mosquito.

Disease Vector
Foul Water Mosquitoes do occasionally create domestic, industrial and agricultural pest problems when they are present in large numbers. Although Western Equine Encephalitis and St. Louis Encephalitis have been isolated from natural populations of these mosquitoes, their reluctance to bite humans reduces their efficiency as disease carriers. This species has recently been identified as a carrier of West Nile Virus, a mosquito-borne disease that is rapidly spreading across the United States.

Life Cycle
Foul Water Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat.

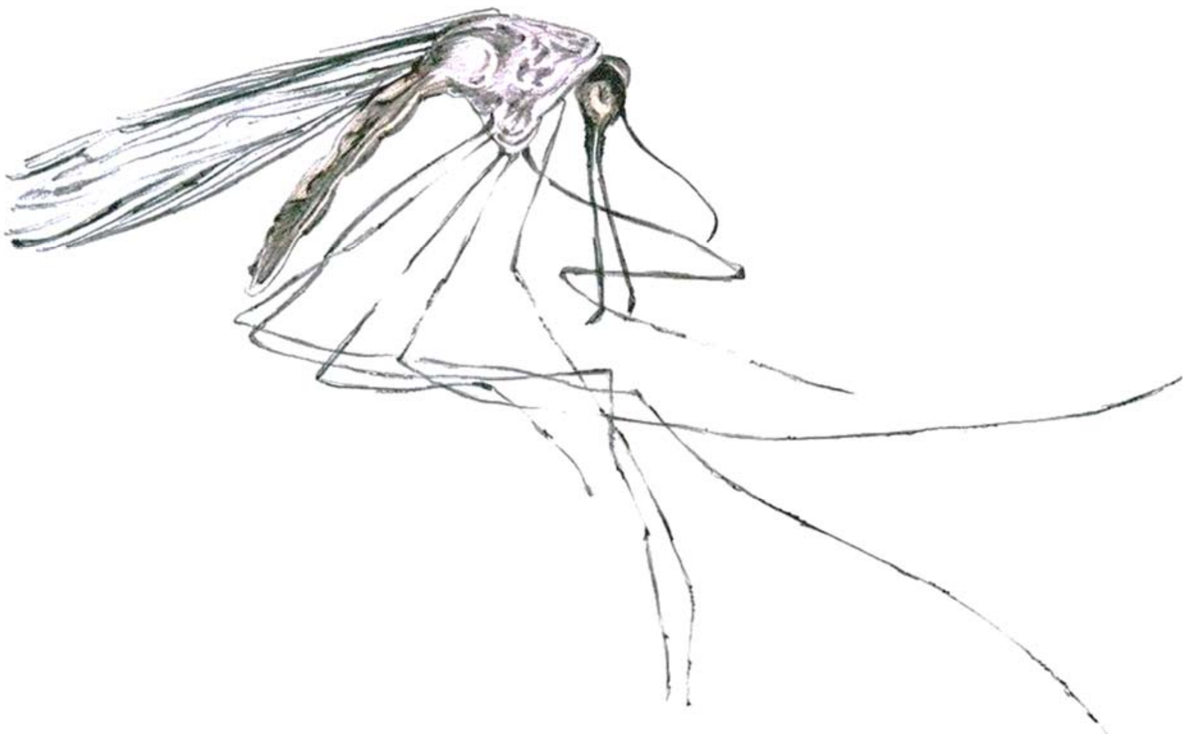
Because they are air breathing organisms they must return to the water's surface to breathe. About one to two weeks are required for larval development. At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges. Under optimum conditions, development from egg to adult takes about a week. However, all mosquito developmental times are dependent on the temperature and nutrients of the water in which they mature.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.



FLOODWATER MOSQUITO

Inland Floodwater Mosquito (*Aedes vexans*)



This is a medium sized brown mosquito with v-shaped notches in the upper abdomen scales. It is one of the most common floodwater mosquitoes and a reported problem species in most states. They are vicious biters and can harbor many viruses including SLE, WEE, eastern equine encephalitis (EEE), and La Cross eencephalitis (LAC), in addition to WNV.

Eggs are laid in mud and hatch when flooded in the spring or early summer. Several hatches may occur each season as water levels recede and rise, however the eggs can remain viable for several years if flooding does not occur.

Larval habitat: Floodwaters, irrigated pastures and other grassland pools
Biting time: dusk through dawn
Preferred host: Birds and mammals
Flight range: 5 to 15 miles from breeding site

Japanese Rockpool Mosquito (*Aedes japonicus*)

Aedes japonicus is an Asian species of mosquito generally found in Japan, Korea, the Ryukyu Archipelago (Okinawa and associated islands), Taiwan, South China, and Hong Kong. In 1998, the subspecies Aedes japonicus japonicus was first detected in the United States in New York and New Jersey. Since that time, Aedes japonicus has been found in six other states: Ohio, Maryland, Connecticut, Massachusetts, Pennsylvania, and Virginia.

Appearance
The adult female of Aedes japonicus is a medium-sized mosquito of dark- to blackish-brown appearance, with white scales on the body and legs.

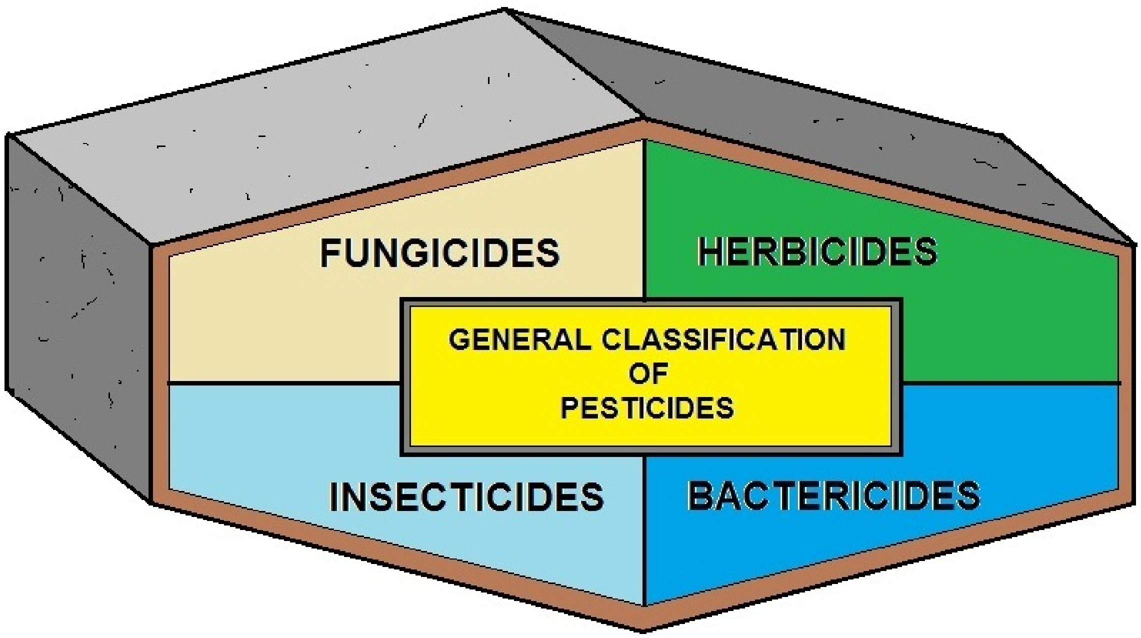
Breeding Areas
Larvae are found in a wide variety of natural and artificial containers, including rock holes and used tires. Preferred sites usually are shaded and contain water rich in organic matter. The similarity of breeding habitats used by Aedes japonicus to those of other Aedes species suggests that the transport of eggs, larvae, and pupae in used tires may be an important mechanism for introducing the species into previously uninfested areas. Eggs are resistant to desiccation and can survive several weeks or months under dry conditions. Aedes japonicus overwinters as eggs in the more northern parts of its range. However, it is found throughout the winter as larvae as far north as Tokyo (37° N), which is equal in latitude to Norfolk, Virginia.

Disease Associations
Although few studies have been done to assess the public and veterinary health importance of Aedes japonicus, this species is suspected of being a vector of Japanese encephalitis (JE) virus to swine in northern Japan. Under experimental conditions it has been shown to transmit JE virus to mice and also to transmit the virus to its progeny through the eggs.

Unpublished studies conducted at the United States Army Medical Research Institute of Infectious Diseases in Fort Detrick, MD, indicate that Aedes japonicus is also a competent experimental vector of West Nile virus, a flavivirus closely related to JE and St. Louis encephalitis viruses.

Behavior
Adult species of Aedes japonicus rest in wooded areas and prefer to bite during the daytime. In the laboratory, they feed readily on chicks and mice, but not on reptiles or amphibians. Further studies on Aedes japonicus are needed to more clearly define their feeding preferences in a variety of situations.

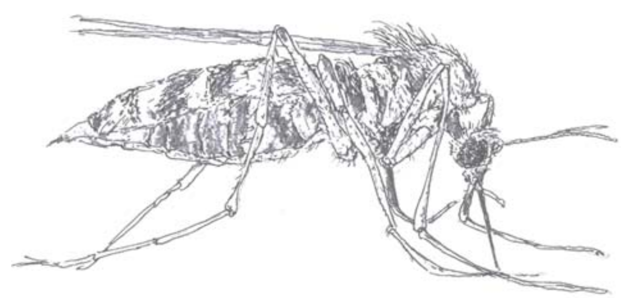
Protection
As with other biting insects, the use of protective clothing (i.e., long-sleeved shirts and long pants) and insect repellent is recommended to prevent bites.



CLASSIFICATION OF PESTICIDES

Northern House Mosquito or House Mosquito (*Culex pipiens)*

Common Associate Species: *Cx. restuans, Cs. inornata, An. punctipennis*


MOSQUITO *(culex pipiens)*

Culex pipiens, the Northern House Mosquito has a distribution that roughly includes the northern half of the United States. This species' range begins just north of Maine, along the Atlantic seaboard, and extends to the state of Washington in the west with some extension into southern British Columbia. The range along the Pacific coast extends into northern California and then east on a relatively straight line to North Carolina. The species is replaced by *Culex quinquefasciatus*, the Southern House Mosquito, in the southern United States with limited overlap in portions of the Midwest.

This species is medium-sized, brownish with pale bands around the abdominal segments. The quickly developing larvae may be continuously present spring through fall. Although they occur in rural environments, they reach their greatest numbers in urban and suburban areas and readily enter homes. Culex pipiens are known to vector St. Lewis encephalitis (SLE).

Larval Habitats
Nearly anything retaining water, clean or polluted— artificial containers, catch basins, ground pools, animal waste lagoons, tires, hoof prints, etc.
Biting time: Night

Preferred host: Mostly birds, but will readily bite mammals, including humans
Flight range: ¼ to ½ mile from breeding site

Culex pipiens provides the life cycle model for most of the domestic *Culex* in temperate areas. Inseminated adult females from the last generation of the season build body fat by feeding on carbohydrates and enter hibernation in fall. The females pass the winter in diapause and do not become active during periods of warm winter weather. Hibernating females are common in basements, outbuildings, and subterranean enclosures. Like *Culex restuans*, the females congregate near moisture and move their resting location during the winter to remain in a humid atmosphere.

Mortality can be extensive during periods of winter drought. Females emerge from hibernation during May and begin depositing egg rafts in suitable habitat. Populations of this mosquito usually peak during August, but breeding continues well into September. The adults from the last generation of the season lose all interest in blood meal hosts but will move in and out of overwintering sites during periods of mild fall weather. Larvae rarely persist in breeding habitats after females have entered hibernation.

Culex pipiens can be found in a fairly wide range of larval habitats, but are generally associated with water that has a high organic content. The species utilizes temporary ground water that ranges from mildly to grossly polluted. The species also deposits its eggs in artificial containers, including tin cans, tires, and any refuse that allows stagnant water to puddle. The species is decidedly urban and reaches greatest numbers in large urban centers. Catch basins and storm drains provide ideal habitat for *Cx. pipiens*. The species becomes particularly abundant in areas where raw sewage leaks into subterranean drainage systems.

Meat packing plants and slaughter house drainage ponds support high populations of this species. *Culex pipiens* can always be collected in the effluent from sewage treatment plants.

Collection
No special techniques are required to collect *Cx. pipiens* larvae. This species is common in urban settings and can usually be found in significant numbers in a variety of habitats where stagnant water collects. *Culex pipiens* will oviposit readily in buckets containing prepared straw infusions. Most piles of discarded tires contain a mixture of *Cx. pipiens* and *Cx. restuans* in addition to the tire-breeding *Aedes*.

Culex pipiens occurs on every continent except Antarctica and is the most widely distributed mosquito in the world. In North America, two races range north (*Cx. pipiens pipiens*) and south (*Cx. pipiens quinquefasciatus*) of 39ºN latitude, about the level of Sacramento. *Cx. p. pipiens* lives in the milder coastal climate areas, while *Cx. p. quinquefasciatus* is found in the warmer inland valleys.

***Culex pipiens*'** main host is wild birds, but it also feeds freely on a wide variety of warm-blooded vertebrates, including man. In northern California, it currently plays only a lesser role as a carrier of human disease, while in southern California and the Gulf Coast region, it is a major carrier of Saint Louis encephalitis. It is also the best known carrier of West Nile Virus, a severe encephalitis virus newly arrived in the Americas that is spreading along the eastern seaboard.

Culex pipiens is a serious pest, called the "*house mosquito*" because it commonly develops in small containers around the home. It shows great skill in finding ways to get into the house, where it feeds on the occupants at night. It also occurs in containers and sumps on farms and industrial plants, in polluted waters, and will feed out-of-doors at night.

Culex pipiens larvae typically develop best in dirty, stagnant water containing abundant organic matter, in ground pools and natural and man-made containers. Vector technicians often find improperly installed or maintained underground septic tanks producing huge numbers of this species. The mosquitoes gain entrance thorough cracks in the ground, through poorly fitting or unsealed covers, or by the vent pipes made for removal of gases.

We recommend that all vents be covered with window screening, preferably aluminum screen, to exclude adults. Polluted habitats do not generally support a very wide variety of species. Most larval samples from polluted water sources consist mainly of *Cx. pipiens* and *Cx restuans*. *Culex pipiens* larvae are easily distinguished from *Cx. restuans* by the length and shape of the antennae.

Culex tarsalis is widely distributed in North America west of the Mississippi River, between southern Canada and northern Mexico. It primarily occurs throughout California, from sea level up to nearly 10,000 in feet elevation, and is especially abundant in the Central Valley and coastal regions, including Marin and Sonoma Counties.

As its name suggests, *C. tarsalis* has bands of white scales around the joints of its tarsi (legs). There is also a pale band around the center of the proboscis, a line of white scales extending along the hind tibia and femur, and a series of V-shaped spots made of dark scales on the underside of each abdominal segment. This mosquito develops rapidly and produces multiple generations. In the hot summer season, egg to adult development occurs in as few as four to ten days.

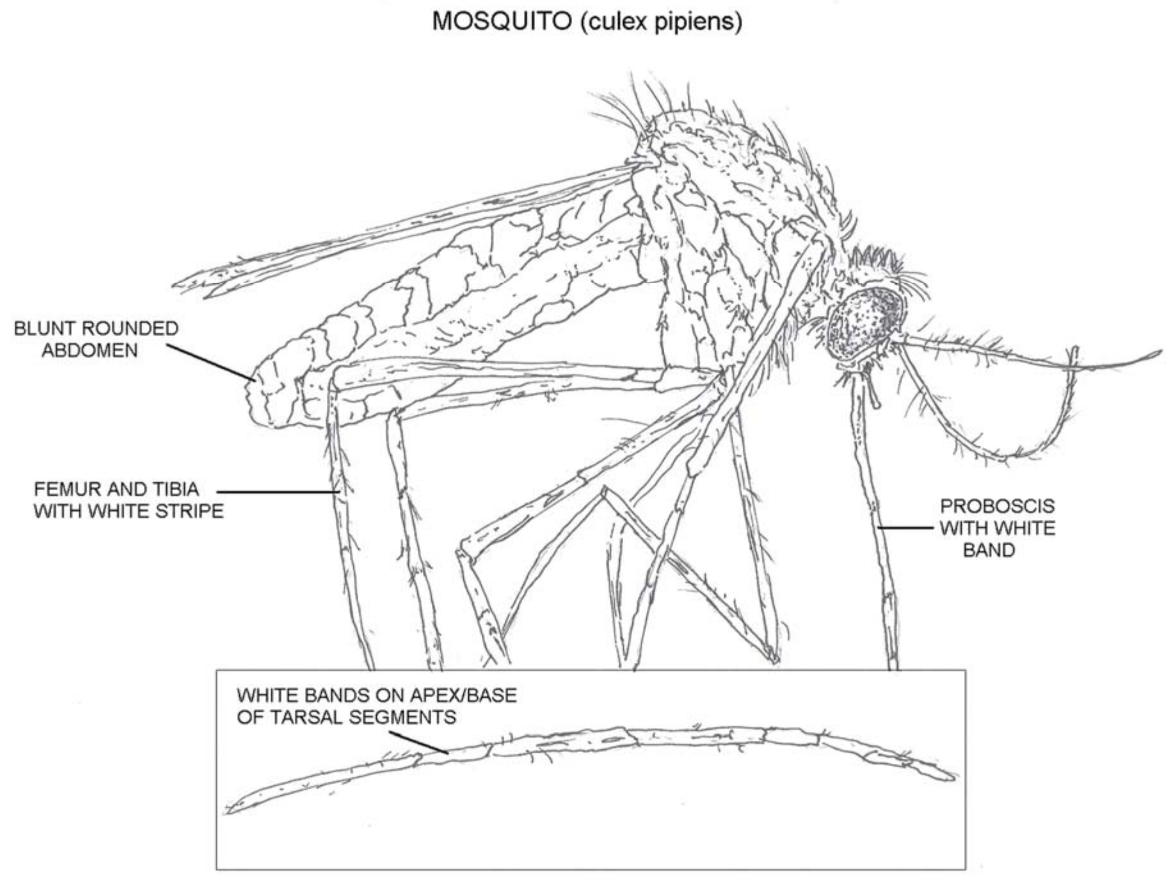
A female can lay six or seven times, with some 300 eggs in a batch. Without control efforts, local populations can reach huge numbers in a short time.

Culex tarsalis breeds in nearly every freshwater source except treeholes. Larvae are found in all but the most polluted ground pools. Summer agricultural irrigation produces an especially favorable environment, with highest population densities coinciding with the months of most intense irrigation.

During the daytime, adults rest in tree cavities, animal burrows, and artificial habitats like barns, chicken houses, and culverts. In most areas, they feed equally on birds and mammals, including man, depending on availability. After years of intense efforts to keep them under control, vast populations in the central valley have become resistant to nearly all the common chemical insecticides.

Culex tarsalis is the most important carrier of western equine and Saint Louis encephalitis in much of the western U.S. It occurs together with wild birds - the natural reservoir of infection, and the virus is often discovered in field-collected specimens. It is also readily infected after taking an infected blood meal, and easily transmits the virus during its later blood meals.

The appearance of antibodies against encephalitis virus in the flocks of sentinel chickens kept in several parts of the state is a signal alarm to the districts to begin quickly and aggressively reducing *Culex tarsalis* numbers around populated areas.



Mosquitoes of the *Culex tarsalis* species have a distinct ring around the proboscis. Also, they have apical and basal tarsal bands. With 11 species, Culex is one of the largest genus of mosquitoes. Females of this group have short palpi and a blunt, rather than pointed abdomen. Unlike most Ochlerotatus, they tend to have numerous generations in a year. Several hundred eggs are laid packed together in rafts. A female can lay six or seven times in her forty to fifty-day life span.

Where does this Mosquito normally lay its Eggs?

- In tin cans, buckets, discarded tires and other artificial containers that hold stagnant water.
- In untended bird baths, clogged rain gutters and plastic wading pools that hold stagnant water.
- In storm drains and catch basins in urban areas.
- In septic seepage and other foul water sources above or below ground level.

How does this Mosquito Overwinter?

- The last generation of adult females' mate and build body fat by feeding on carbohydrates.
- Mated females find refuge in culverts, basements, and protected areas that stay above freezing.
- The body metabolism slows considerably and winter is spent in a state of torpor.
- Females that survive the winter blood feed in spring and lay eggs that produce the summer populations.

Antennal Shape

The characteristic antennal shape is difficult to see in the dipper, but the slightly longer, constricted antennae and prominent antennal tufts can be discerned with practice. The multiple hair tufts on the siphon can be used as a diagnostic character under the microscope. *Culex salinarius* is a closely related species that is easily distinguished by the longer, more slender siphon.

St. Louis Encephalitis

SLE is a natural infection found in a variety of wild birds. Culex pipiens can function as a vector and pass the virus from one bird to the next. If virus is introduced to an urban setting, Culex pipiens can amplify the infection in urban birds. House Sparrows, an introduced species, circulate exceptionally high levels of SLE when they become infected. Culex pipiens that bite infected birds acquire the virus and are capable of passing it on to humans.

Summary

- Culex pipiens is usually the most common pest mosquito in urban and suburban settings.
- Culex pipiens is an indicator of polluted water in the immediate vicinity.
- Culex pipiens is recognized as the primary vector of St. Louis encephalitis (**SLE**).
- Culex pipiens is normally considered to be a bird feeder.
- Some urban strains have a predilection for mammalian hosts and feed readily on humans.
- Most populations probably contain individuals that accept blood from mammals as well as birds.

Pale Marsh Mosquito (*Ochlerotatus dorsalis)*

Ochlerotatus dorsalis' common name comes from its whitish-grey appearance: the abdomen and wings have intermixed narrow light and dark scales. Sometimes the light scales predominate. The hind legs have pale white bands overlapping the individual joints. This mosquito is found in Asia, Europe, and North America.

In California, it occurs along the Pacific coast and in the eastern regions of the state. It breeds along the edges of bays, marshes and lakes. It is especially frequent in the seasonally flooded marshes along the edges of the San Francisco and San Pablo Bays.

A strong flyer, ***Ochlerotatus dorsalis*** often disperses 20 miles or more from its breeding sources. Unlike most other local *Ochlerotatus*, the pale marsh mosquito is active almost year-around. Females produce continuous broods throughout the spring and summer, with 8 to 12 hatches each year, and the last adults emerging in October.

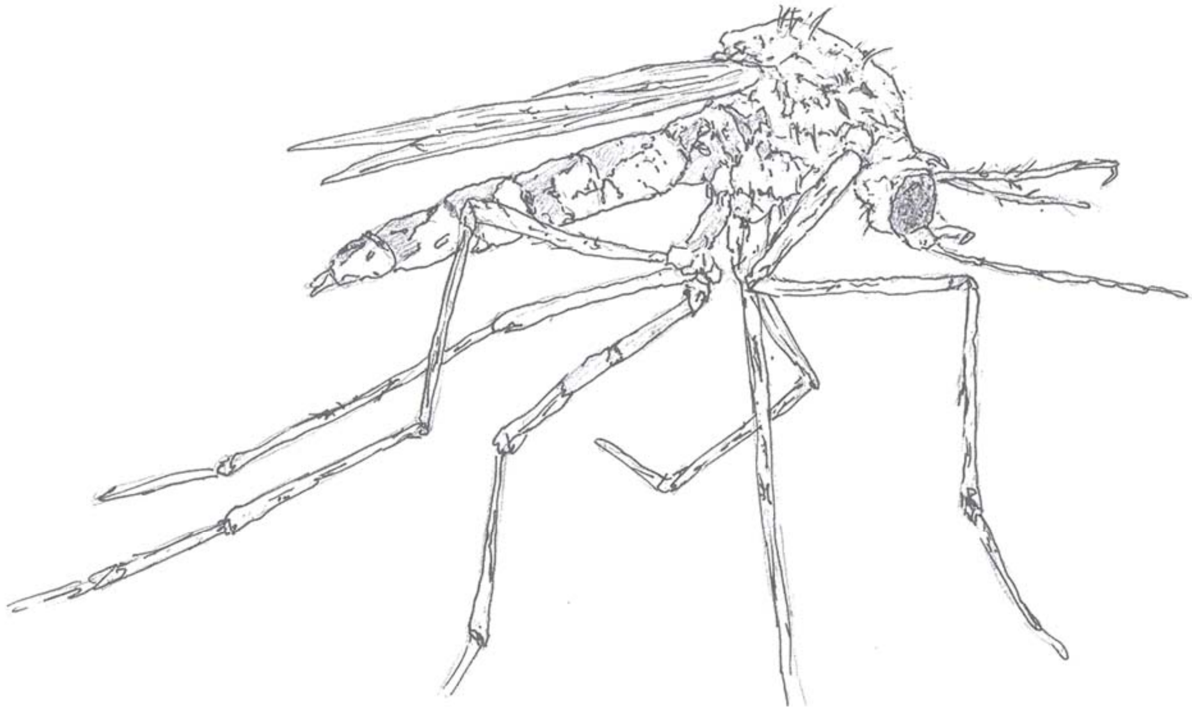
Pre-adult stages can be as short as 1 to 2 weeks in the warm summer weather. Populations sometimes build up to huge numbers in brackish marshes subject to prolonged spring flooding.

Ochlerotatus dorsalis is a serious pest mosquito and a secondary vector of the encephalitis virus. Females prefer to feed on large mammals like cattle and horses (and man) when these are available.

They are vicious biters, and so aggressive and persistent that livestock tend to move away from areas where they are numerous.

Ochlerotatus dorsalis

Salt Marsh Mosquito, Aedes (Ochlerotatus taeniorynchus)



SALT MARSH MOSQUITO

The major salt marsh mosquito, Aedes (Ochlerotatus) taeniorynchus, is known for its fierce biting plus synchronized egg laying and hatching patterns that produce large swarms. Adult mosquitoes are small, fragile insects with slender bodies; one pair of narrow wings (tiny scales are attached to wing veins); and three pairs of long, slender legs. They vary in length from 3/16 to 1/2 inch. Mosquitoes have an elongate "beak" or piercing proboscis. Eggs are elongate, usually about 1/40-inch-long, and dark brown to black near hatching. Larvae or "wigglers" are filter feeders that move with an S-shaped motion. Larvae undergo four growth stages called instars before they molt into the pupa or "tumbler" stage. Pupae are comma-shaped and nonfeeding and appear to tumble through the water when disturbed.

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas.

By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas. Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas. The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment.

Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public. Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Mosquito Repellents

The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

Shaggy-legged" Gallinipper (*Psorophora ciliate*)

Is the largest blood sucking mosquito in the U.S. Commonly referred to as the "Shaggy-legged" Gallinipper. It is easy to identify by its large size and it inflicts a painful bite. Rarely found in large numbers. The larvae are large and are predacious upon other larvae.

Larval habitat: Breeds in fields, temporary ground pools, and ditches.
Adult habitat: Fields and yards
Biting activity: Anytime of the day when disturbed.
Flight range: 1-2 miles

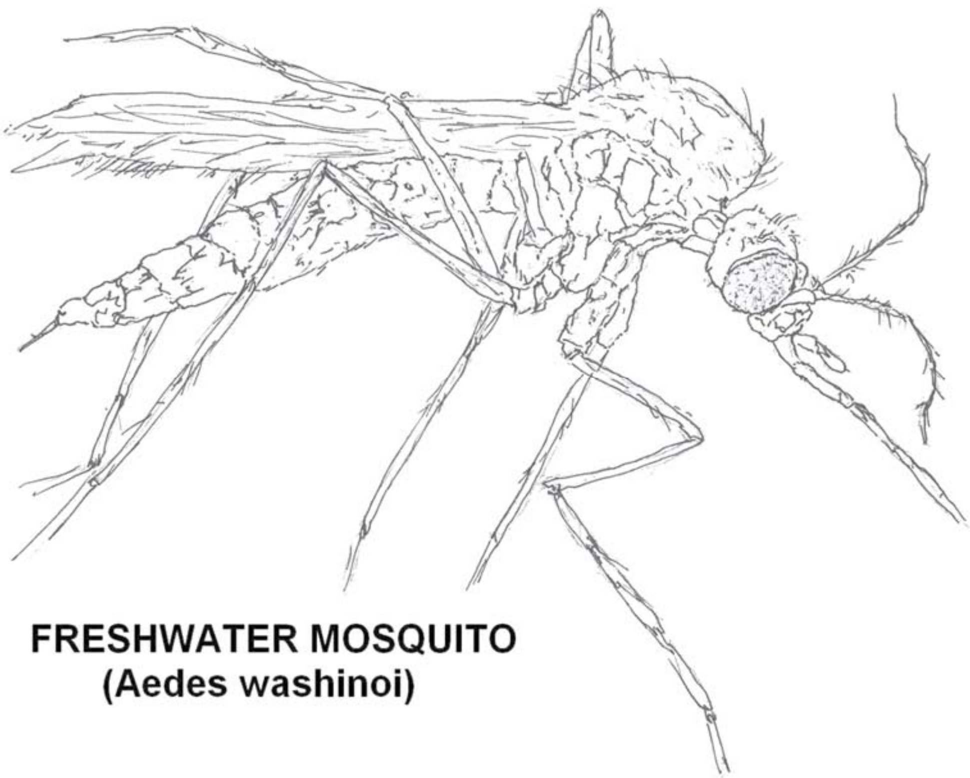
Snow Mosquito (*Culisetain ornate*)

SNOW MOSQUITO

This species also rather large, grayish-brown with broad, pale-scaled wings. The fertilized females hibernate in winter and emerge during warm spells, even when snow is still on the ground. It continues to breed throughout spring and summer. Known to vector WEE and is implicated in WNV.

Larval habitat: often in cold, fairly clean water
Biting time: Dusk through dawn, temperature influenced
Preferred host: Wild and domestic mammals, usually not humans
Flight range: unknown

Washino's Willow Pool Mosquitoes (*Aedes washinoi)*



FRESHWATER MOSQUITO
(Aedes washinoi)

Washino's Willow Pool Mosquito (Aedes washinoi) is an aggressive day-biting mosquito commonly found breeding in shallow ground pools and riparian sites dominated by willow or cottonwood trees. This species has also been found breeding in areas with dense blackberry thickets. Washino's Willow Pool Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. Washino's Willow Pool Mosquito does occasionally create domestic, industrial and agricultural pest problems when they are present in large numbers. Although California Encephalitis virus has been isolated from natural populations of these mosquitoes, no confirmed human cases of mosquito-borne disease has been linked to this species of mosquito.

Life Cycle

After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat. Because they are air breathing organisms they must return to the water's surface to breathe. About one to two weeks are required for larval development.

At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges.

Adult Daily Activity
Adults emerge during late winter and early spring and can persist through early June. Man-made canals and natural water ways have sometimes been used by these mosquitoes as a passage way into local human developments.

Adult Flight Range
Usually stay within one mile of their breeding site. Maximum recorded flight range 1.5 miles.

Adult Feeding
Females tend to feed during the day and at dusk. Their preferred hosts are humans and large mammals.

Eggs and Larvae
Eggs are laid in the muddy margins adjacent to the receding water line of the larval habitat and hatch the following winter when reflooded. Larvae usually hatch during early winter after sufficient rainfall has filled their habitat with enough water to submerge the last season and prior season's eggs. Additional hatches of larvae can occur if late winter and early spring rains refill drying larval sites. Larva of this mosquito also exhibit a late fourth instar diapause and partial synchronous adult emergence similar to that observed in the Winter Salt Marsh Mosquito (Aedes squamiger).

Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

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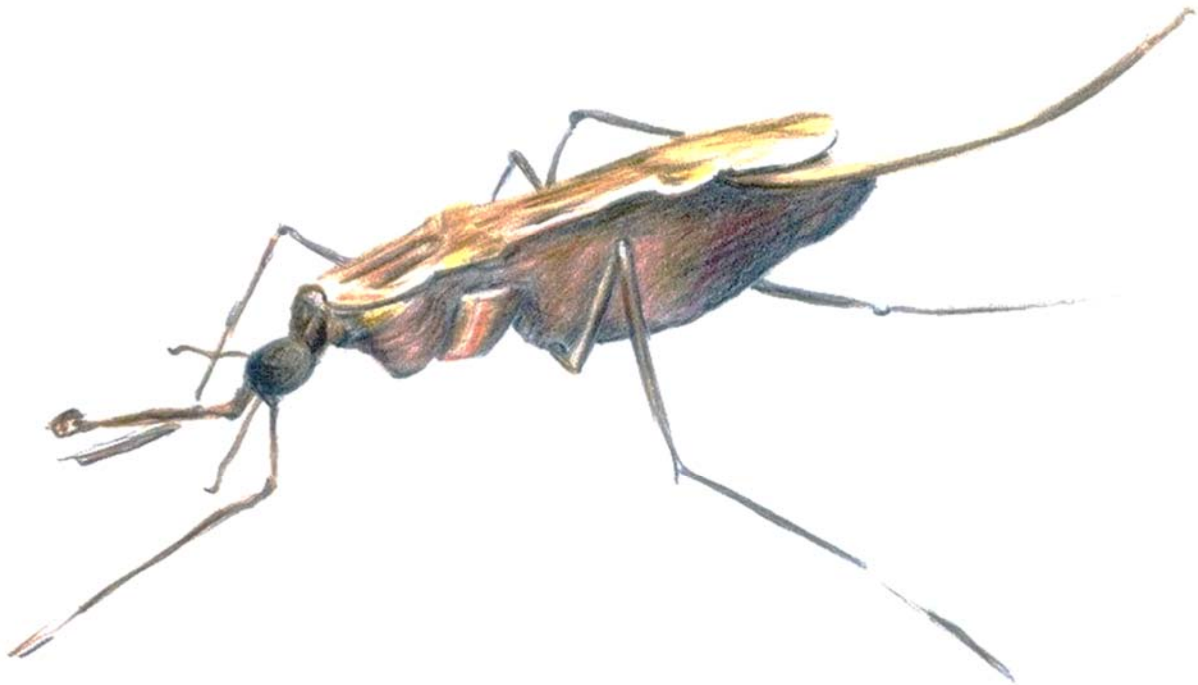
Western Encephalitis Mosquito (*Culex tarsalis*)



This is medium-sized, dark mosquito that has a broad white band across the middle of the proboscis and the lower leg segments. In addition to being a potential vector of WNV this species is the most important vector of Western Equine encephalitis (WEE) and SLE.

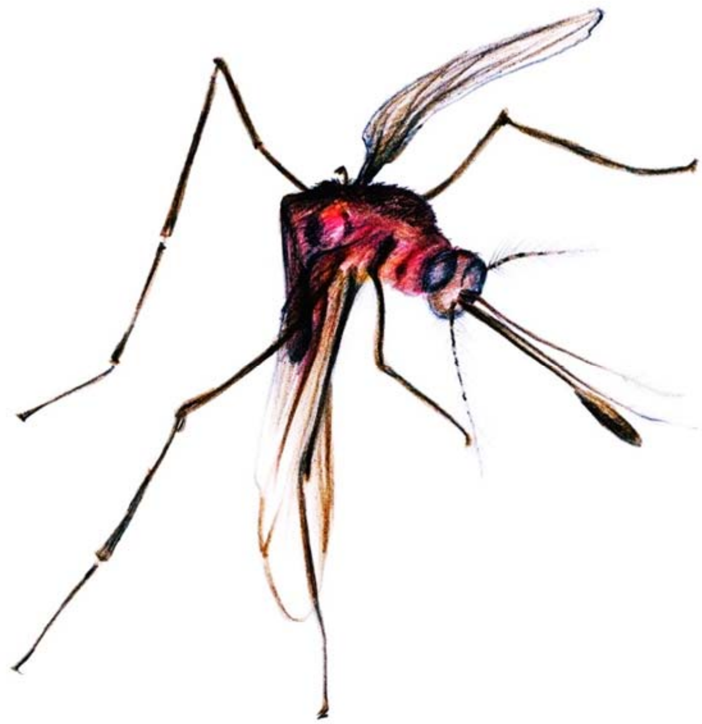
Larval habitat: Nearly anything retaining water (see Culex pipiens)
Biting time: Most active at nightfall but also through until daylight
Preferred host: Mostly birds, but will readily bite mammals, including humans
Flight range: 5-15 miles

Mosquito Repellents
The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:
1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.

5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

OCHLEROTATUS FITCHII

Western Malaria Mosquito (*Anopheles freeborni)*

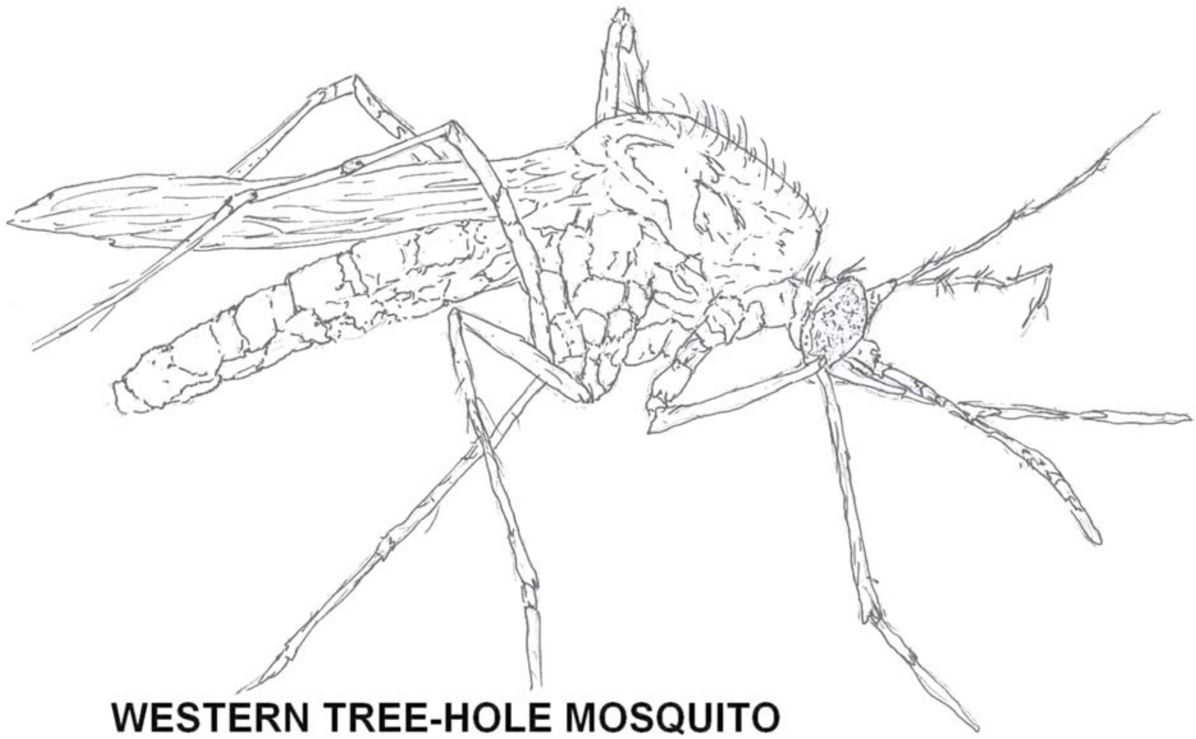


Anopheles freeborni is the most important malaria vector in California. In our lifetime, endemic malaria has been eradicated from the U.S. But in our grandparents' time, it was so serious that education guidelines called for it to be included in the instructional program in every primary school. Today, carrier mosquitoes still occur throughout the state, and hundreds of active infections are discovered every year in tourists and immigrants from other countries.

Anopheles are easily distinguished from other mosquitoes: their eggs are laid individually and have small floats on each side; the larvae lack the long breathing tube found in other mosquitoes; adults have hairs, but no scales on the abdomen and both sexes have palpi as long as the proboscis. Feeding females assume a distinctive pose with their abdomen pointed high in the air.

Western malaria mosquitoes occur west of the Rocky Mountains, between southern Canada and northern Mexico, and from sea level to about 6,000 ft. elevation. The larvae prefer clear, clean water, in sunlit or partially shaded streams or ponds. They occur abundantly in both Marin and Sonoma counties, but their highest density is found in the irrigated and seasonally flooded rice fields of the great central valley, historically the region of California's highest malaria infection rates. Adults migrate in the spring and fall, but most stay within five miles of their larval sites. Like most *Anopheles*, they are active during the hours of darkness, and find shelter in hidden places during the day. Females feed mainly on medium to large mammals like rabbits, deer, cattle or horses, and they pursue and bite man aggressively.

Western Treehole Mosquito (*Aedes sierrensis*)



WESTERN TREE-HOLE MOSQUITO
(Aedes sierrensis)

The Western Treehole Mosquito (Aedes sierrensis) is brightly marked with white scales which contrast with its dark body. It also has an unbanded proboscis (beak), white banded tarsi (feet) and a pointed tipped abdomen. The Western Treehole Mosquito (Aedes sierrensis) received its name because the immature stages are frequently found in water contained in rot holes of trees such as oak, laurel, madrone, eucalyptus and other local species.

This mosquito is found in most California counties and is the primary vector of Dog Heartworm disease in the Western United States. Western Treehole Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. Western Treehole Mosquitoes are a serious pest problem when they are present in large numbers. This mosquito is the primary vector of Dog Heartworm Disease in the coastal and foothill communities of California.

Wrigglers
After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Feeding occurs when they hang from the water's surface by the tip of their tail (siphon) or by browsing along the bottom of their habitat. Because they are air breathing organisms they must return to the water's surface to breathe. Larval development varies from ten days to five months depending on weather conditions with developmental completion occurring around the spring equinox (late March).

At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This can take four or more days during which time feeding does not occur. When the transformation is completed, the new adult splits the pupal skin and emerges.

Adult Daily Activity
Adults begin to emerge with the advent of the spring equinox, requiring a 12-hour day length to trigger emergence. Males tend to hover around potential hosts of the female, seizing her in flight when she approaches, to mate with her. Male mating swarms also occur in the shaded areas of this mosquito's habitat. Adults can live up to several months depending on temperature, humidity and other climactic factors. They are frequent pests in residential and recreational areas April through August where large numbers of trees are present.

Adult Flight Range: This mosquito has a limited flight range staying very close to its breeding site.

Adult Feeding: Adults feed predominantly on small mammals but will feed on large mammals and humans when available. Peak feeding activity occurs at dusk, although host feeding does sometimes occur during the day and night. Treehole Mosquitoes prefer to feed outdoors (but sometimes enter homes) during the mid-morning and late afternoon. Like all species of mosquitoes, only the female mosquito takes a blood meal (bites).

Eggs and Larvae: Eggs are laid individually inside moist treeholes, crotches of trees, and containers with damp leafy debris. Eggs usually hatch the next season following flooding with early winter rainfall. It should be noted that the eggs of this species can survive for many years before hatching, with only part of each batch hatching during a single season. Larval development can take ten days to five months to complete, depending on quantity of rainfall and other environmental conditions.

Dog Heartworm Disease
Dog Heartworm Disease is a clinical condition in dogs caused by a roundworm, Dirofilaria immitis, which resides within the dog's heart and lungs. This disease, a serious and possibly fatal veterinary problem, is associated with dogs, coyotes and foxes. Canine Heartworm is transmitted by the bite of an infected Western Treehole Mosquito. The adult worm lives in the right side of the heart and the adjacent large blood vessels and lungs, where it may attain a length of 6-12 inches. Many other mosquito species feed on dogs, but the Western Treehole Mosquito is the most common carrier of heartworm.

Disease Symptoms
The outward symptoms of the disease are not noticeable in most cases until reduced blood flow caused by adult worms damages the heart, lungs, liver and kidneys. Advanced symptoms of heartworm may include: rapid tiring, shortness of breath, chronic soft dry cough, listlessness and weight loss. If you live in or travel to areas where treehole mosquitoes occur, check with your veterinarian regarding treatment and prevention. Drugs are available to prevent the disease, and it is curable if diagnosed in the early stages. The time of highest risk for dogs to contract heartworm is April through August; however, unseasonable rainfall may extend this period.

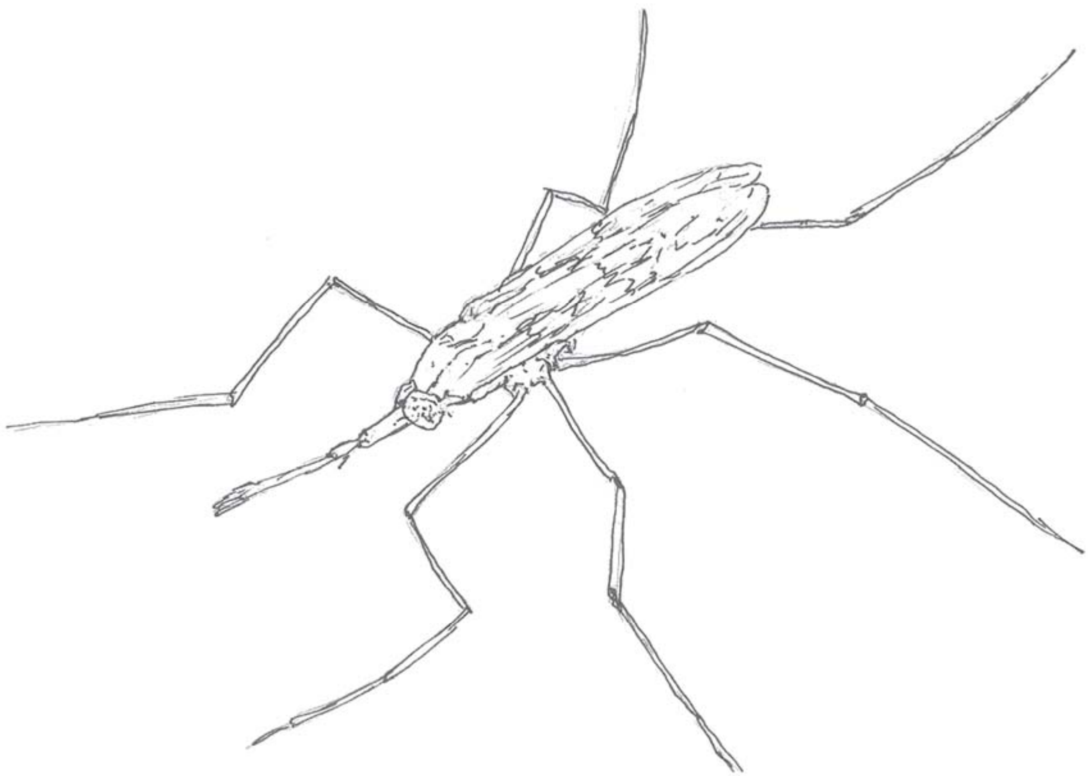
Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

An important consideration in the practice of mosquito control is the advisability, whenever possible, to target control operations against immature populations. These stages are usually concentrated, relatively immobile and therefore occupy minimum acreage compared with adults, which may rapidly disperse over large areas. By targeting the immatures, it is possible to minimize the area treated and often avoid treating populated areas. Conversely, targeting adult mosquitoes may require highly visible and extensive applications of adulticides within residential and urban areas.

The adulticides registered for this use are applied at levels 100 to 10,000 times below rates that would be cause for concern about exposure risk for the general public or the environment. Nevertheless, achieving good larval control while at the same time minimizing the use of adulticides is environmentally and client friendly, and appreciated by the public.

Most states have specific regulations governing the decision to apply pesticides for mosquito control. These usually involve the collection of data that substantiate the need for the application. Thus, standardized ultra-low-volume (ULV) operation on a fixed schedule is not allowed in most areas. Each application must be justified by documentation of increased mosquito activity, such as trap collections, landing or biting counts, telephone complaints, etc.

Woodland Malaria Mosquito (*Anopheles punctipennis*)



WOODLAND MALARIA MOSQUITO
(Anopheles punctipennis)

The wings have conspicuous pale and dark spots and palpi that are entirely dark. They are aggressive biters and readily enter homes.

Larval habitat: Woodland pools containing vegetation and in artificial containers and other environments associated with Culex tarsalis and Culex pipiens.
Biting time: Day and dusk
Preferred host: large mammals including cows, horses, and human
Flight range: 0 to ¼ mile from breeding site

Woodland Malaria Mosquitoes have four life stages: egg, larva, pupa, and adult. The immature stages need standing water to complete their life cycle. After an adult female lays her eggs they hatch into larvae (wrigglers), which feed on small organic particles and microorganisms in the water. Because they are air breathing organisms they must return to the water's surface to breathe.

About one to two weeks are required for larval development. At the end of the larval stage, the mosquito molts and becomes the aquatic pupa (tumbler). The pupa is active only if disturbed, for this is the resting stage where the larval form is transformed into the adult. This takes about two days during which time feeding does not occur.

When the transformation is completed, the new adult splits the pupal skin and emerges. Under optimum conditions, development from egg to adult takes about three weeks. However, all mosquito developmental times are dependent on the temperature and nutrients of the water in which they mature.

Where possible, the best approach is to prevent mosquitoes from breeding by modifying their breeding sites. Careful planning and coordinated efforts with landowners, regulatory agencies and concerned citizens is essential for any creek or stream enhancement project.

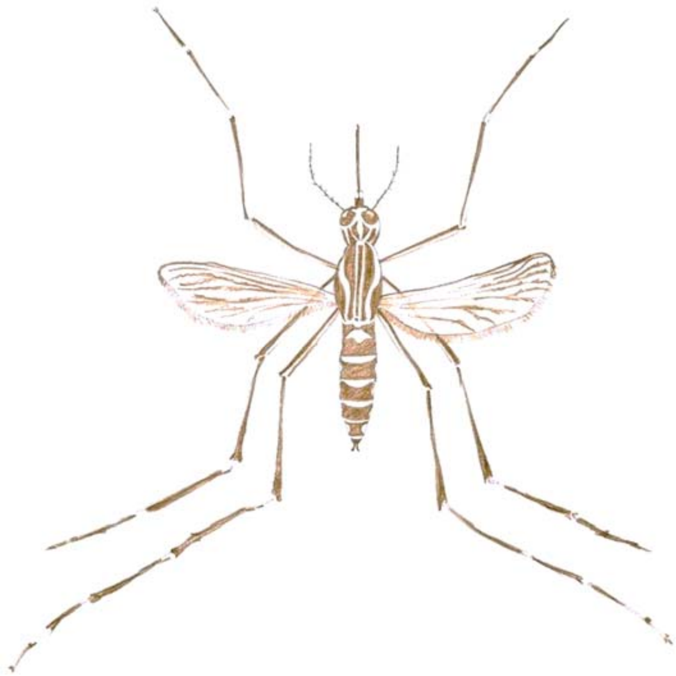
Where possible, the best approach is to prevent mosquitoes from breeding by eliminating or modifying breeding sites. This can be accomplished best by eliminating containers which are capable of holding water. Where breeding sites exist in standing or slow-moving water, corrective action to permanently eliminate them by such means as filling, pumping, ditching or draining is recommended. Close coordination with your local mosquito abatement district and environmental regulatory authorities is recommended.

Mosquito Repellents

The CDC traveler's page on preventing dengue fever suggests using mosquito repellents that contain DEET (N, N-diethylmetatoluamide, between 20% to 30% concentration, but not more). It also suggests the following:

1. The mosquito usually bites at dusk and dawn but may bite at any time during the day – especially indoors, in shady areas, or when the weather is cloudy.
2. The mosquito's preferred breeding areas are in areas of stagnant water, such as flower vases, uncovered barrels, buckets, and discarded tires, but the most dangerous areas are wet shower floors and toilet tanks, as they allow the mosquitos to breed in the residence. Research has shown that certain chemicals emanating from bacteria in water containers stimulate the female mosquitoes to lay their eggs. They are particularly motivated to lay eggs in water containers that have the correct amounts of specific fatty acids associated with bacteria involved in the degradation of leaves and other organic matter in water. The chemicals associated with the microbial stew are far more stimulating to discerning female mosquitoes than plain or filtered water in which the bacteria once lived.
3. Wear long-sleeved clothing and long trousers when outdoors during the day and evening.
4. Spray permethrin or DEET repellents on clothing, as mosquitos may bite through thin clothing.
5. Use mosquito netting over the bed if the bedroom is not air conditioned or screened. For additional protection, treat the mosquito netting with the insecticide permethrin.
6. Spray permethrin or a similar insecticide in the bedroom before retiring.

Yellow Fever Mosquito (*Aedes aegypti*)
Roland Mortimer, Rio de Janeiro



The yellow fever mosquito belongs to the tribe Aedini of the dipteran family Culicidae and to the genus Aedes and subgenus Stegomyia. According to the recent analyses, some authors raised the subgenus Stegomyia of the genus Aedes to the level of genus. The proposed name change has not been completely accepted; at least one scientific journal, the Journal of Medical Entomology, has officially encouraged authors dealing with aedine mosquitoes to continue to use the traditional names.

Although the lifespan of an adult Aedes aegypti is between two to four weeks depending on conditions, Aedes aegypti's eggs can be viable for over a year in a dry state, which allows the mosquito to re-emerge after a cold winter or dry spell.

The yellow fever mosquito (Aedes aegypti) genome is being sequenced by The Broad Institute and The Institute for Genomic Research (TIGR). The initial assembly was released in August 2005; a draft sequence of the genome and preliminary analysis was published in June 2007. Annotation of the sequence is being undertaken by VectorBase and TIGR. Aedes aegypti is a vector for transmitting several tropical fevers. Only the female bites for blood which she needs to mature her eggs. Understanding how the mosquito detects its host is a crucial step in the spread of the disease.

Aedes aegypti are attracted to chemical compounds that are emitted by mammals. These compounds include ammonia, carbon dioxide, lactic acid, and octenol. Scientists at the Agricultural Research Service have studied the specific chemical structure of octenol in order to better understand why this chemical attracts the mosquito to its host. They found that the mosquito has a preference for “right-handed” (dextrorotatory) octenol molecules. The term “right-handed” refers to the specific orientation of the molecule, which can either be “right-handed” or “left –handed.”

This discovery helps scientists understand how the mosquito seeks out its host and may enable them to develop more effective forms of mosquito repellant.

There are many types of mosquitoes living in the tropical and sub-tropical regions of the world. We can roughly divide them into two groups--Culex and Aedes--but perhaps one of the most important is ***Aedes aegypti***. According to the World Health Organization, the virus for Dengue fever is the most important arbovirus to man in the world, and since *Aedes* has been found to transmit this virus, it has been widely studied and blamed as the vector.

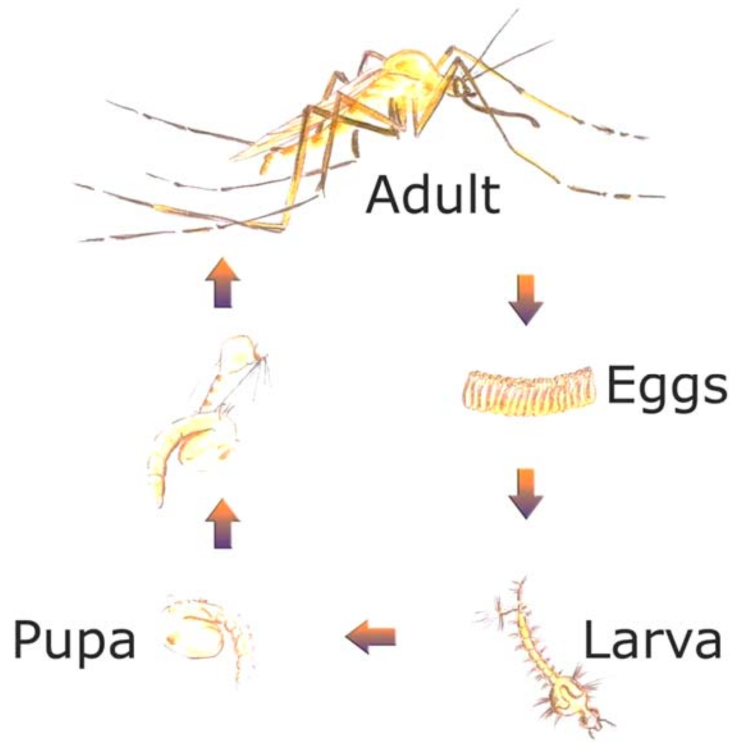
This mosquito is small in comparison to others, usually between three to four millimeters in length, discounting leg length. It is totally black, apart from white '*spots*' on the body and head regions and white rings on the legs. The thorax is decorated with a white '*Lyre*' shape, of which the 'chords' are two dull yellow lines. Its wings are translucent and bordered with scales.

At rest, the insect turns up its hind legs in a curved fashion and usually cleans them by rubbing one against the other, or exercises them by crossing them and alternately raising and lowering them.

Many people believe mosquitoes only live two or three days, but in actual fact, left unmolested, they can live for months. The males of all species of mosquitoes do not bite humans or animals of any species, they live on fruit.

Only the female bites for blood, which she needs to mature her eggs. The eggs of most species are laid together in a raft form, but *Aedes* lays her eggs separately, thus allowing them to spread over large surfaces of water if conditions permit. In this way, the eggs stand a better chance of survival. When freshly laid, the eggs are white, but soon turn black in color. The young larvae feed on bacteria in the water and soon cast their skins as they rapidly grow.

Most types of mosquito species can lay their eggs in any type of water, mainly dirty or even polluted. Not *Aedes*, she only lays her eggs in clean water which contains no other living species.



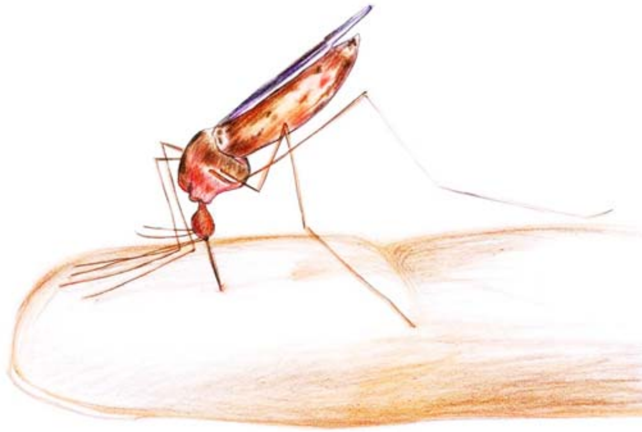
Many people have died from Dengue fever and many more around the world suffer terribly because of this species. The male mosquito is much more beautiful. His antennae looking like large plumes and the palpi long and adorned with feathery hairs. After a few weeks, or even shorter in the summer, the larvae reach the pupa stage. This stage is usually very short, and the pupae rise to the surface of the water, where the top of the pupal case opens, like the lid on a can, and out emerges the new adult.

Aedes aegypti, unlike other species, is very intelligent, if one could say that mosquitoes are intelligent. They arrived in Brazil from Ethiopia with the slave trading ships. Living near man for so long she has become totally dependent on him and has learned a lot from him. For instance, she has greatly reduced the `humming' sound she makes with her wings so man cannot hear it, unlike other species whose humming is extremely irritating and awakens the deepest sleeper.

She never lives more than ninety meters from dwellings, thus guaranteeing her meals. She attacks from below or behind, usually from underneath desks or chairs and mainly at the feet and ankles. The insect is very fast in flight, unless gorged with blood. Other types of mosquitoes even fly into your face and can be easily caught or killed--not *Aedes*, she's too smart!

The eggs can survive for very long periods in a dry state, often for more than a year. Since the virus can be passed from adult to egg, the virus, too, is guaranteed survival until the next summer and heavy rains. The virus remains in the salivary glands of the mosquito, and when she bites for food, she injects saliva into the wound where the anti-coagulants contained in her saliva facilitate feeding. Without knowing it, she also injects the virus into the host.

Mosquito Disease Section

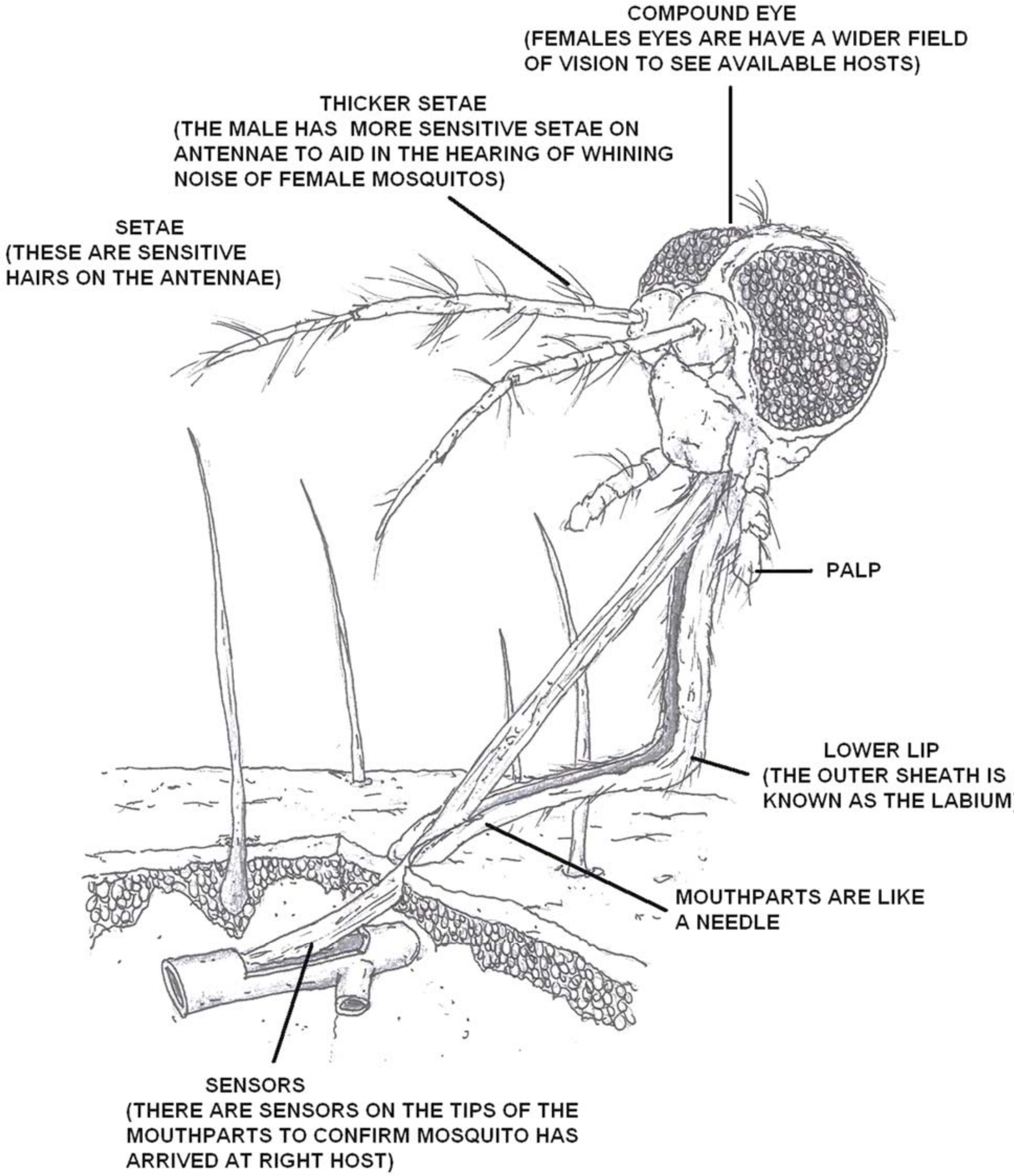


Female of the malaria vector mosquito, *Anopheles gambiae* taking a blood meal.

Mosquitoes were already feeding on blood during the days of the dinosaurs. Many viruses, bacteria, protozoans, worms, and other parasitic organisms have spent millions of years adapting their own life cycles to the intimate relationships between biting arthropods and their hosts. In a kind of lottery-of-life, every successful agent has evolved and fine-tuned each detail of its existence to the ecology and natural history of its two very different kinds of hosts.

Mosquito believed to be thousands of years old preserved in amber.

Vector-borne diseases that affect agriculture, like equine encephalitis, canine heartworm, or bluetongue of sheep, have received a lot of attention by scientists. The vast majority affect only wildlife populations, and still very little is known about these insects. Some bacterial and viral agents have only recently been discovered, when new diagnostic tools identified a previously unrecorded organism in a human patient. The normal vertebrate hosts of most vector-borne diseases of man (malaria is now almost an exception) are wild or domestic animals. Humans usually become infected only when they step into an already existing natural or "*enzootic*" cycle. Diseases caused by organisms currently exploring these newly opened transmission routes to man have been called "*emerging infectious diseases.”*



COMPOUND EYE
(FEMALES EYES ARE HAVE A WIDER FIELD OF VISION TO SEE AVAILABLE HOSTS)
THICKER SETAE
(THE MALE HAS MORE SENSITIVE SETAE ON ANTENNAE TO AID IN THE HEARING OF WHINING NOISE OF FEMALE MOSQUITOS)
SETAE
(THESE ARE SENSITIVE HAIRS ON THE ANTENNAE)
PALP
LOWER LIP
(THE OUTER SHEATH IS KNOWN AS THE LABIUM)
MOUTHPARTS ARE LIKE A NEEDLE
SENSORS
(THERE ARE SENSORS ON THE TIPS OF THE MOUTHPARTS TO CONFIRM MOSQUITO HAS ARRIVED AT RIGHT HOST)

Arboviral Encephalitides Mosquito Diseases

Perspectives
Arthropod-borne viruses, i.e., arboviruses, are viruses that are maintained in nature through biological transmission between susceptible vertebrate hosts by blood feeding arthropods (mosquitoes, psychodids, ceratopogonids, and ticks). Vertebrate infection occurs when the infected arthropod takes a blood meal. The term 'arbovirus' has no taxonomic significance. Arboviruses that cause human encephalitis are members of three virus families: the Togaviridae (genus Alphavirus), Flaviviridae, and Bunyaviridae.

Complex Life Cycles
All arboviral encephalitides are zoonotic, being maintained in complex life cycles involving a nonhuman primary vertebrate host and a primary arthropod vector. These cycles usually remain undetected until humans encroach on a natural focus, or the virus escapes this focus via a secondary vector or vertebrate host as the result of some ecologic change. Humans and domestic animals can develop clinical illness but usually are "dead-end" hosts because they do not produce significant viremia, and do not contribute to the transmission cycle. Many arboviruses that cause encephalitis have a variety of different vertebrate hosts and some are transmitted by more than one vector. Maintenance of the viruses in nature may be facilitated by vertical transmission (e.g., the virus is transmitted from the female through the eggs to the offspring).

Global Distribution
Arboviral encephalitides have a global distribution, but there are four main virus agents of encephalitis in the United States: eastern equine encephalitis (EEE), western equine encephalitis (WEE), St. Louis encephalitis (SLE) and La Crosse (LAC) encephalitis, all of which are transmitted by mosquitoes. Another virus, Powassan, is a minor cause of encephalitis in the northern United States, and is transmitted by ticks. A new Powassan-like virus has recently been isolated from deer ticks. Its relatedness to Powassan virus and its ability to cause disease has not been well documented. Most cases of arboviral encephalitis occur from June through September, when arthropods are most active. In milder (i.e., warmer) parts of the country, where arthropods are active late into the year, cases can occur into the winter months.

The majority of human infections is asymptomatic or may result in a nonspecific flu-like syndrome. Onset may be insidious or sudden with fever, headache, myalgias, malaise and occasionally prostration. Infection may, however, lead to encephalitis, with a fatal outcome or permanent neurologic sequelae. Fortunately, only a small proportion of infected persons' progress to frank encephalitis. Experimental studies have shown that invasion of the central nervous system (CNS), generally follows initial virus replication in various peripheral sites and a period of viremia.

Viral transfer from the blood to the CNS through the olfactory tract has been suggested. Because the arboviral encephalitides are viral diseases, antibiotics are not effective for treatment and no effective antiviral drugs have yet been discovered. Treatment is supportive, attempting to deal with problems such as swelling of the brain, loss of the automatic breathing activity of the brain and other treatable complications like bacterial pneumonia.

No Commercially Available Human Vaccines

There are no commercially available human vaccines for these U.S. diseases. There is a Japanese encephalitis vaccine available in the U.S. A tick-borne encephalitis vaccine is available in Europe. An equine vaccine is available for EEE, WEE and Venezuelan equine encephalitis (VEE). Arboviral encephalitis can be prevented in two major ways: personal protective measures and public health measures to reduce the population of infected mosquitoes. Personal measures include reducing time outdoors particularly in early evening hours, wearing long pants and long sleeved shirts and applying mosquito repellent to exposed skin areas. Public health measures often require spraying of insecticides to kill juvenile (larvae) and adult mosquitoes.

Selection of mosquito control methods depends on what needs to be achieved; but, in most emergency situations, the preferred method to achieve maximum results over a wide area is aerial spraying. In many states aerial spraying may be available in certain locations as a means to control nuisance mosquitoes. Such resources can be redirected to areas of virus activity. When aerial spraying is not routinely used, such services are usually contracted for a given time period.

Financing of aerial spraying costs during large outbreaks is usually provided by state emergency contingency funds. Federal funding of emergency spraying is rare and almost always requires a federal disaster declaration. Such disaster declarations usually occur when the vector-borne disease has the potential to infect large numbers of people, when a large population is at risk and when the area requiring treatment is extensive. Special large planes maintained by the United States Air Force can be called upon to deliver the insecticide(s) chosen for such emergencies. Federal disaster declarations have relied heavily on risk assessment by the CDC.

Laboratory diagnosis of human arboviral encephalitis has changed greatly over the last few years. In the past, identification of antibody relied on four tests: hemagglutination-inhibition, complement fixation, plaque reduction neutralization test, and the indirect fluorescent antibody (IFA) test. Positive identification using these immunoglobulin M (IgM) - and IgG-based assays requires a four-fold increase in titer between acute and convalescent serum samples.

With the advent of solid-phase antibody-binding assays, such as enzyme-linked immunosorbent assay (ELISA), the diagnostic algorithm for identification of viral activity has changed. Rapid serologic assays such as IgM-capture ELISA (MAC-ELISA) and IgG ELISA may now be employed soon after infection. Early in infection, IgM antibody is more specific, while later in infection, IgG antibody is more reactive. Inclusion of monoclonal antibodies (MAbs) with defined virus specificities in these solid phase assays has allowed for a level of standardization that was not previously possible.

Virus isolation and identification have also been useful in defining viral agents in serum, cerebrospinal fluid and mosquito vectors. While virus isolation still depends upon growth of an unknown virus in cell culture or neonatal mice, virus identification has also been greatly facilitated by the availability of virus-specific MAbs for use in IFA assays. Similarly, MAbs with avidities sufficiently high to allow for specific binding to virus antigens in a complex protein mixture (e.g., mosquito pool suspensions) have enhanced our ability to rapidly identify virus agents in situ. While polymerase chain reaction (PCR) has been developed to identify a number of viral agents, such tests have not yet been validated for routine rapid identification in the clinical setting.

Mosquito-borne Encephalitis

Mosquito-borne encephalitis offers a rare opportunity in public health to detect the risk of a disease before it occurs and to intervene to reduce that risk substantially. The surveillance required to detect risk is being increasingly refined by the potential utilization of these new technologies which allows for rapid identification of dangerous viruses in mosquito populations. These rapid diagnostic techniques used in threat recognition can shorten public health response time and reduce the geographic spread of infected vectors and thereby the cost of containing them. The Arbovirus Diseases Branch of NCID's Division of Vector-Borne Infectious Diseases has responsibility for CDC's programs in surveillance, diagnosis, research and control of arboviral encephalitides.

La Crosse Encephalitis

La Crosse (LAC) encephalitis was discovered in La Crosse, Wisconsin in 1963. Since then, the virus has been identified in several Midwestern and Mid-Atlantic states. During an average year, about 75 cases of LAC encephalitis are reported to the CDC. Most cases of LAC encephalitis occur in children under 16 years of age. LAC virus is a Bunyavirus and is a zoonotic pathogen cycled between the daytime-biting treehole mosquito, Aedes triseriatus, and vertebrate amplifier hosts (chipmunks, tree squirrels) in deciduous forest habitats. The virus is maintained over the winter by transovarial transmission in mosquito eggs. If the female mosquito is infected, she may lay eggs that carry the virus, and the adults coming from those eggs may be able to transmit the virus to chipmunks and to humans.

Historically, most cases of LAC encephalitis occur in the upper Midwestern states (Minnesota, Wisconsin, Iowa, Illinois, Indiana, and Ohio). Recently, more cases are being reported from states in the mid-Atlantic (West Virginia, Virginia and North Carolina) and southeastern (Alabama and Mississippi) regions of the country. It has long been suspected that LAC encephalitis has a broader distribution and a higher incidence in the eastern United States, but is under-reported because the etiologic agent is often not specifically identified.

LAC encephalitis initially presents as a nonspecific summertime illness with fever, headache, nausea, vomiting and lethargy. Severe disease occurs most commonly in children under the age of 16 and is characterized by seizures, coma, paralysis, and a variety of neurological sequelae after recovery. Death from LAC encephalitis occurs in less than 1% of clinical cases. In many clinical settings, pediatric cases presenting with CNS involvement are routinely screened for herpes or enteroviral etiologies. Since there is no specific treatment for LAC encephalitis, physicians often do not request the tests required to specifically identifying LAC virus, and the cases are reported as aseptic meningitis or viral encephalitis of unknown etiology. Also found in the United States, Jamestown Canyon and Cache Valley viruses are related to LAC, but rarely cause encephalitis.

Eastern Equine Encephalitis

Eastern equine encephalitis (EEE) is also caused by a virus transmitted to humans and equines by the bite of an infected mosquito. EEE virus is an alphavirus that was first identified in the 1930's and currently occurs in focal locations along the eastern seaboard, the Gulf Coast and some inland Midwestern locations of the United States. While small outbreaks of human disease have occurred in the United States, equine epizootics can be a common occurrence during the summer and fall.

It takes from 4-10 days after the bite of an infected mosquito for an individual to develop symptoms of EEE. These symptoms begin with a sudden onset of fever, general muscle pains, and a headache of increasing severity. Many individuals will progress to more severe symptoms such as seizures and coma. Approximately one-third of all people with clinical encephalitis caused by EEE will die from the disease and of those who recover, many will suffer permanent brain damage with many of those requiring permanent institutional care.

In addition to humans, EEE virus can produce severe disease in: horses, some birds such as pheasants, quail, ostriches and emus, and even puppies. Because horses are outdoors and attract hordes of biting mosquitoes, they are at high risk of contracting EEE when the virus is present in mosquitoes. Human cases are usually preceded by those in horses and exceeded in numbers by horse cases which may be used as a surveillance tool.

EEE virus occurs in natural cycles involving birds and Culiseta melanura, in some swampy areas nearly every year during the warm months. Where the virus resides or how it survives in the winter is unknown. It may be introduced by migratory birds in the spring or it may remain dormant in some yet undiscovered part of its life cycle. With the onset of spring, the virus reappears in the birds (native bird species do not seem to be affected by the virus) and mosquitoes of the swamp. In this usual cycle of transmission, virus does not escape from these areas because the mosquito involved prefers to feed upon birds and does not usually bite humans or other mammals.

For reasons not fully understood, the virus may escape from enzootic foci in swamp areas in birds or bridge vectors such as Coquilletidia perturbans and Aedes sollicitans. These species feed on both birds and mammals and can transmit the virus to humans, horses, and other hosts. Other mosquito species such as Ae. vexans and Culex nigripalpus can also transmit EEE virus. When health officials maintain surveillance for EEE virus activity, this movement out of the swamp can be detected, and if the level of activity is sufficiently high, can recommend and undertake measures to reduce the risk to humans.

Western Equine Encephalitis

The alphavirus western equine encephalitis (WEE) was first isolated in California in 1930 from the brain of a horse with encephalitis, and remains an important cause of encephalitis in horses and humans in North America, mainly in western parts of the USA and Canada. In the western United States, the enzootic cycle of WEE involves passerine birds, in which the infection is in apparent, and culicine mosquitoes, principally Cx. tarsalis, a species that is associated with irrigated agriculture and stream drainages. The virus has also been isolated from a variety of mammal species.

Other important mosquito vector species include Aedes melanimon in California, Ae. dorsalis in Utah and New Mexico and Ae. campestris in New Mexico. WEE virus was isolated from field collected larvae of Ae. dorsalis, providing evidence that vertical transmission may play an important role in the maintenance cycle of an alphavirus.

Expansion of irrigated agriculture in the North Platte River Valley during the past several decades has created habitats and conditions favorable for increases in populations of granivorous birds such as the house sparrow, Passer domesticus, and mosquitoes such as Cx. tarsalis, Aedes dorsalis and Aedes melanimon.

All of these species may play a role in WEE virus transmission in irrigated areas. In addition to Cx. tarsalis, Ae. dorsalis and Ae. melanimon, WEE virus also has been isolated occasionally from some other mosquito species present in the area. Two confirmed and several suspect cases of WEE were reported from Wyoming in 1994. In 1995, two strains of WEE virus were isolated from Culex tarsalis and neutralizing antibody to WEE virus was demonstrated in sera from pheasants and house sparrows. During 1997, 35 strains of WEE virus were isolated from mosquitoes collected in Scotts Bluff County, Nebraska.

Human WEE cases are usually first seen in June or July. Most WEE infections are asymptomatic or present as mild, nonspecific illness. Patients with clinically apparent illness usually have a sudden onset with fever, headache, nausea, vomiting, anorexia and malaise, followed by altered mental status, weakness and signs of meningeal irritation. Children, especially those under 1-year-old, are affected more severely than adults and may be left with permanent sequelae, which is seen in 5 to 30% of young patients. The mortality rate is about 3%.

St. Louis Encephalitis

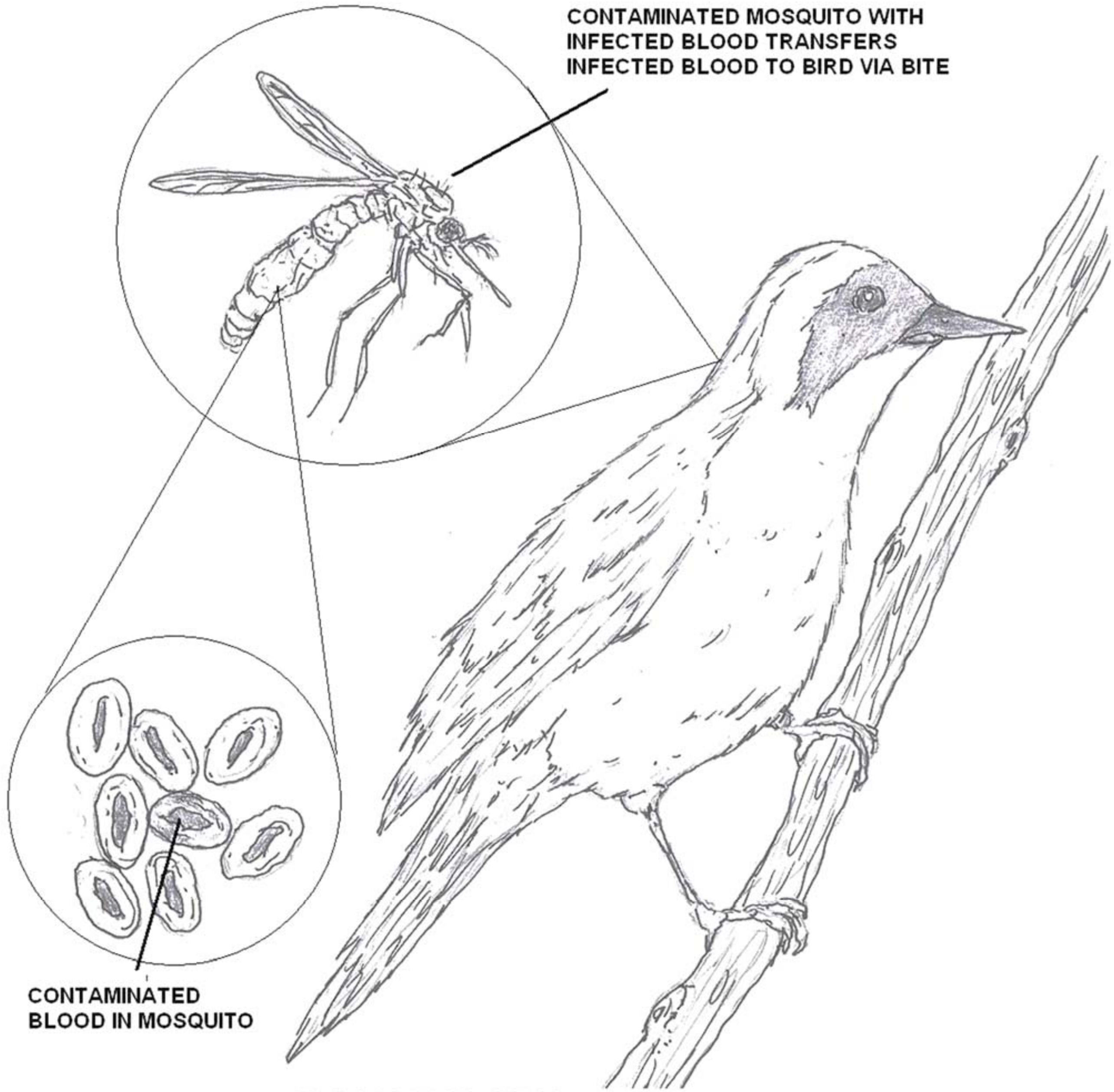
In the United States, the leading cause of epidemic flaviviral encephalitis is St. Louis encephalitis (SLE) virus. SLE is the most common mosquito-transmitted human pathogen in the U.S. While periodic SLE epidemics have occurred only in the Midwest and southeast, SLE virus is distributed throughout the lower 48 states. Since 1964, there have been 4,437 confirmed cases of SLE with an average of 193 cases per year (range 4 - 1,967). However, less than 1% of SLE viral infections are clinically apparent and the vast majority of infections remain undiagnosed. Illness ranges in severity from a simple febrile headache to meningoencephalitis, with an overall case-fatality ratio of 5-15 %. The disease is generally milder in children than in adults, but in those children who do have disease, there is a high rate of encephalitis.

The elderly are at highest risk for severe disease and death. During the summer season, SLE virus is maintained in a mosquito-bird-mosquito cycle, with periodic amplification by peridomestic birds and Culex mosquitoes. In Florida, the principal vector is Cx. nigripalpus, in the Midwest, Cx. pipiens pipiens and Cx. p. quinquefasciatus and in the western United States, Cx. tarsalis and members of the Cx. pipiens complex.

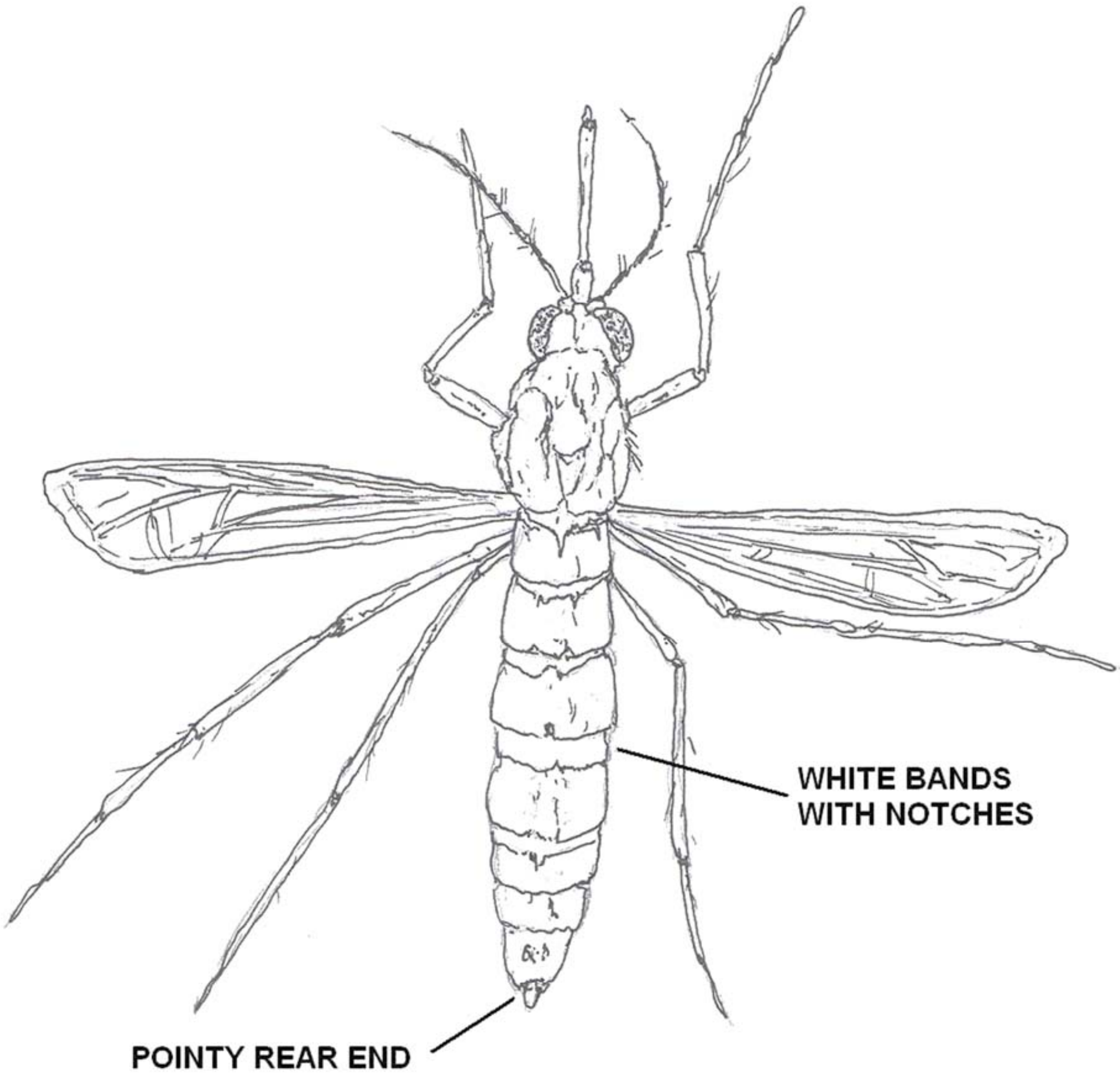
Powassan Encephalitis

Powassan (POW) virus is a flavivirus and currently the only well documented tick-borne transmitted arbovirus occurring in the United States and Canada. Recently a Powassan-like virus was isolated from the deer tick, Ixodes scapularis. Its relationship to POW and its ability to cause human disease has not been fully elucidated. POW's range in the United States is primarily in the upper tier States.

In addition to isolations from man, the virus has been recovered from ticks (Ixodes marxi, I. cookei and Dermacentor andersoni) and from the tissues of a skunk (Spiligale putorius). It is a rare cause of acute viral encephalitis. POW virus was first isolated from the brain of a 5-year-old child who died in Ontario in 1958. Patients who recover may have residual neurological problems.



AVIAN MALARIA



INLAND FLOODWATER MOSQUITO
(Aedes vexans)

Venezuelan Equine Encephalitis

Like EEE and WEE viruses, Venezuelan equine encephalitis (VEE) is an alphavirus and causes encephalitis in horses and humans and is an important veterinary and public health problem in Central and South America. Occasionally, large regional epizootics and epidemics can occur resulting in thousands of equine and human infections. Epizootic strains of VEE virus can infect and be transmitted by a large number of mosquito species. The natural reservoir host for the epizootic strains is not known. A large epizootic that began in South America in 1969 reached Texas in 1971. It was estimated that over 200,000 horses died in that outbreak, which was controlled by a massive equine vaccination program using an experimental live attenuated VEE vaccine. There were several thousand human infections. A more recent VEE epidemic occurred in the fall of 1995 in Venezuela and Colombia with an estimated 90,000 human infections. Infection of man with VEE virus is less severe than with EEE and WEE viruses, and fatalities are rare. Adults usually develop only an influenza-like illness, and overt encephalitis is usually confined to children. Effective VEE virus vaccines are available for equines.

Enzootic strains of VEE virus have a wide geographic distribution in the Americas. These viruses are maintained in cycles involving forest dwelling rodents and mosquito vectors, mainly Culex (Melanoconion) species. Occasional cases or small outbreaks of human disease are associated with these viruses, the most recent outbreaks were in Venezuela in 1992, Peru in 1994 and Mexico in 1995-96.

Other Arboviral Encephalitides

Many other arboviral encephalitides occur throughout the world. Most of these diseases are problems only for those individuals traveling to countries where the viruses are endemic.

Japanese Encephalitis

Japanese encephalitis (JE) virus is a flavivirus, related to SLE, and is widespread throughout Asia. Worldwide, it is the most important cause of arboviral encephalitis with over 45,000 cases reported annually. In recent years, JE virus has expanded its geographic distribution with outbreaks in the Pacific. Epidemics occur in late summer in temperate regions, but the infection is enzootic and occurs throughout the year in many tropical areas of Asia. The virus is maintained in a cycle involving culicine mosquitoes and water birds. The virus is transmitted to man by Culex mosquitoes, primarily Cx. tritaeniorhynchus, which breed in rice fields. Pigs are the main amplifying hosts of JE virus in peridomestic environments.

The incubation period of JE is 5 to 14 days. Onset of symptoms is usually sudden, with fever, headache and vomiting. The illness resolves in 5 to 7 days if there is no CNS involvement. The mortality in most outbreaks is less than 10%, but is higher in children and can exceed 30%. Neurologic sequelae in patients who recover are reported in up to 30% of cases. A formalin-inactivated vaccine prepared in mice is used widely in Japan, China, India, Korea, Taiwan and Thailand. This vaccine is currently available for human use in the United States, for individuals who might be traveling to endemic countries.

Tick-Borne Encephalitis

Tick-borne encephalitis (TBE) is caused by two closely related flaviviruses which are distinct biologically. The eastern subtype causes Russian spring-summer encephalitis (RSSE) and is transmitted by Ixodes persulcatus, whereas the western subtype is transmitted by Ixodes ricinus and causes Central European encephalitis (CEE). The name CEE is somewhat misleading, since the condition can occur throughout much of Europe. Of the two subtypes, RSSE is the more severe infection, having a mortality of up to 25% in some outbreaks, whereas mortality in CEE seldom exceeds 5%. The incubation period is 7 to 14 days. Infection usually presents as a mild, influenza-type illness or as benign, aseptic meningitis, but may result in fatal meningoencephalitis. Fever is often biphasic, and there may be severe headache and neck rigidity, with transient paralysis of the limbs, shoulders or less commonly the respiratory musculature.

A few patients are left with residual paralysis. Although the great majority of TBE infections follow exposure to ticks, infection has occurred through the ingestion of infected cows' or goats' milk. An inactivated TBE vaccine is currently available in Europe and Russia.

West Nile Encephalitis

WNV is a flavivirus belonging taxonomically to the Japanese encephalitis serocomplex that includes the closely related St. Louis encephalitis (SLE) virus, Kunjin and Murray Valley encephalitis viruses, as well as others. WNV was first isolated in the West Nile Province of Uganda in 1937 (2). The first recorded epidemics occurred in Israel during 1951-1954 and in 1957. Epidemics have been reported in Europe in the Rhone delta of France in 1962 and in Romania in 1996 (3-5). The largest recorded epidemic occurred in South Africa in 1974 (6).

An outbreak of arboviral encephalitis in New York City and neighboring counties in New York state in late August and September 1999, was initially attributed to St. Louis encephalitis virus based on positive serologic findings in cerebrospinal fluid (CSF) and serum samples using a virus-specific IgM-capture enzyme-linked immunosorbent assay (ELISA).

The outbreak has been subsequently confirmed as caused by West Nile virus based on the identification of virus in human, avian, and mosquito samples. See also Outbreak of West Nile-Like Viral Encephalitis -- New York, 1999. MMWR, 1999:48(38);845-9 and Update: West Nile-Like Viral Encephalitis -- New York, 1999. MMWR, 1999:48(39);890-2. A recent outbreak WN encephalitis occurred in Bucharest, Romania in 1996.

The virus that caused the New York area outbreak has been definitively identified as a strain of WNV. The genomic sequences identified to date from human brain, virus isolates from zoo birds, dead crows, and mosquito pools are identical. SLE and West Nile viruses are antigenically related, and cross reactions are observed in most serologic tests. The isolation of viruses and genomic sequences from birds, mosquitoes, and human brain tissue permitted the discovery of West Nile virus in North America and prompted more specific testing. The limitations of serologic assays emphasize the importance of isolating the virus from entomologic, clinical, or veterinary material.

Although it is not known when and how West Nile virus was introduced into North America, international travel of infected persons to New York or transport by imported infected birds may have played a role.

WNV can infect a wide range of vertebrates; in humans it usually produces either asymptomatic infection or mild febrile disease, but can cause severe and fatal infection in a small percentage of patients. Within its normal geographic distribution of Africa, the Middle East, western Asia, and Europe, WNV has not been documented to cause epizootics in birds; crows and other birds with antibodies to WNV are common, suggesting that asymptomatic or mild infection usually occurs among birds in those regions. Similarly, substantial bird virulence of SLE virus has not been reported. Therefore, an epizootic producing high mortality in crows and other bird species is unusual for either WNV or SLE virus. For both viruses, migratory birds may play an important role in the natural transmission cycles and spread. Like SLE virus, WNV is transmitted principally by Culex species mosquitoes, but also can be transmitted by Aedes, Anopheles, and other species. The predominance of urban Culex pipiens mosquitoes trapped during this outbreak suggests an important role for this species. Enhanced surveillance for early detection of virus activity in birds and mosquitoes will be crucial to guide control measures.

Yellow Fever

Yellow fever is still an important disease despite scientific advances in understanding the disease and the development of an effective vaccine. The continued appearance of yellow fever epidemics and the potential for large epidemics of this disease is of real concern. The ability to reduce human suffering due to yellow fever depends on being able to use efficient and effective mosquito control coupled with a massive vaccination program. Both are extremely difficult to accomplish in many regions of the world where the risk for a yellow fever outbreak may be greatest. Successful mosquito control against Aedes aegypti has reduced the number of yellow fever cases in many cities.

However, mosquito control resources may be non-existent and delivery of vaccine insufficient. In the 1990s the worldwide annual production of yellow fever vaccine was about 15 million doses with demands on vaccine extremely unpredictable. A vaccination program that is geared to regions in advance of an expected epidemic is cost-effective, but it is unlikely to be successful because of the time delay in identifying the epidemic and that it takes 5-7 days for the vaccine to provide any protection after inoculation. On the other hand, a campaign to vaccinate the entire population in the absence of yellow fever would be extremely costly and require a long-term commitment to vaccinate everyone.

History of Yellow Fever

Yellow fever is among the most feared of human diseases. It was one of the most devastating and important diseases in Africa and the Americas in the 17-20th centuries with periodic outbreaks of yellow fever that involved thousands of human cases. New Orleans experienced the last major yellow fever epidemic in the United States in 1905 with about 4000 human cases and 500 deaths.

Yellow fever virus is transmitted to humans through the bite of infected mosquitoes. Epidemics of yellow fever during the past 300 years show why this disease inspired dread and fear. The numbers of deaths during outbreaks are startling: 6,000 dead in Barbados in 1647; 3,500 deaths in Philadelphia in 1793; 1,500 in New York City in 1798; 29,000 deaths in Haiti in 1802; and 20,000 deaths in over 100 American towns in 1878.

It was not until 1901 that yellow fever transmission to humans was associated with the blood-feeding by the Aedes aegypti mosquito. The larval habitat for this species is primarily containers such as barrels, buckets, cisterns, and vases.

Eliminating the larval habitat was instrumental in controlling yellow fever. This was accomplished by either removing the container, or modifying containers by covering the openings with screen, for example, to prevent female mosquitoes from laying eggs in the water container. During the 20th century yellow fever has re-emerged as a cause of human suffering. Recent epidemics include 100,000 cases and 30,00 deaths in Ethiopia in 1960-62; 17,500 cases with 1,700 deaths in Upper Volta in 1983; and Cameroon had 20,000 cases with 1,000 deaths in 1990. The World Health Organization officially reported 18,735 yellow fever cases with 4,522 deaths for the period 1987 – 1991.

What is Yellow Fever?
The Disease

Yellow fever is particularly feared due to the disturbing nature of its symptoms. Symptoms may range from clinically inapparent to fatal. In some regions of Latin America as much as 90% of the population have been infected with the yellow fever virus but show no clinical symptoms. After being bitten by an infected mosquito, the incubation period in infected humans is generally 3-6 days. The onset of the disease is very sudden and devastating to the patient. There is high fever (102o – 104o F), headache, malaise, back pain, chills, prostration, nausea, slow pulse and vomiting. The virus can be found in the blood of the patient for about 4 days following the bite of the mosquito, and during this period the patient is capable of infecting more mosquitoes. Some individuals show a rapid recovery at this point and the symptoms stop. This phase can last from 3-4 days.

Severe yellow fever cases also have symptoms that can subside but then return in a day or so. This is the diphase part of the progression of the disease. Twenty to fifty percent of people who enter the second phase will die from yellow fever.
Symptoms include fever, vomiting, abdominal pain, prostration, dehydration, jaundice due to liver involvement, internal bleeding, bleeding of the nose, mouth, and gums, blood in the urine, and kidney or liver failure. The internal bleeding results in blood in the vomit, called “black vomit” due to the color, and dark stools. No virus is in the blood at this point so the patient is not infectious to mosquitoes.

Death usually occurs between the 7th and 10th day of the illness showing the quickness with which the disease can act and the reason it is so dreaded. Some very severe atypical cases of yellow fever may die as early as 3 days after the onset of symptoms. Mortality from yellow fever approaches 10% of clinical cases but has reached as high as 50% of those people developing symptoms.

There is no cure for yellow fever. Treatment is only supportive in an attempt to reduce the severity of the symptoms. However, the disease is preventable. An excellent vaccine is available to provide protection against yellow fever. It was first developed by Dr. Max Theiler in the 1930s and is called the 17D vaccine. In 1951 Dr. Theiler received a Nobel Prize for this extraordinary contribution. This vaccine provides excellent protection against yellow fever for as long as 10 years after vaccination and some people still are protected 30-35 years after being vaccinated. People traveling to areas where yellow fever is known to cause disease should be vaccinated in advance. Current information for travelers can be found at the Centers for Disease Control website for travelers' health: http://wwwnc.cdc.gov/travel/

The Virus

Yellow fever virus is a member of the group of viruses called flaviviruses. The virus has been found in the tropical regions of the Americas, Africa, and there have been historical yellow fever incursions in parts of North America and Europe. The yellow fever virus has never been detected in Asia, Australia or the Pacific despite the presence of Aedes aegypti in these regions. The reason for this is unknown and the subject of much speculation.

Insect Transmission

Several different mosquito species transmit yellow fever virus depending on the geographic region and habitat. The most important mosquito species involved worldwide in the transmission of yellow fever to humans is Aedes aegypti, also known as “the yellow fever mosquito.” The association of yellow fever transmission to humans by Aedes aegypti was a major breakthrough in understanding this dreaded disease. In 1901, Major Walter Reed, U. S. Army, lead the studies showing the role of Aedes aegypti. The species is widely distributed throughout the tropics and subtropics of the world. Larvae of Aedes aegypti can develop in a variety of artificial containers, i.e., flower pots, tires, water jars, many commonly found around human habitats. Adult Aedes aegypti have a distinct preference for humans as a source of blood.

Chikungunya

Chikungunya is suspected when there is epidemic disease with the characteristic triad of symptoms of fever, rash and joint pain. Chikungunya can easily be confused with another mosquito-borne human pathogen called Dengue. The definitive diagnosis of Chikungunya requires laboratory testing. The virus can be detected during the first 48 hours of disease, and may be detected as late as day 4 in some patients. Usually Chikungunya is diagnosed by detecting patient antibodies produced by the immune response to the virus and found in the blood. Antibodies to CHIKV persist in the blood in excess of 6 months.

Chikungunya is a virus that can be transmitted to humans by mosquitoes. The resulting illness is also called Chikungunya. It was originally described in the early 1950s after an outbreak in a Swahili village on the Makonde plateau that lies between Tanzania and Mozambique. The translation of Chikingunya from Makonde means “illness of the bended walker,” “that which bends up,” stooped over, walking bent over, or “bended walker.” In India, it is known as Aakyda, meaning “stiff man” and Maakyda meaning “monkey-like”. These words refer to the arthritic condition that occurs in some patients which gives rise to a stooped posture. The virus was first found in Asia, isolated in Bangkok, Thailand in 1958.

The Virus

Chikungunya virus, or CHIKV is a member of the Alphavirus genus in the family Togaviridae. CHIKV is related to other alphaviruses like Ross River, Sindbis and Venezuelan equine encephalitis viruses.

What are the symptoms?

Reported symptoms include fever, chills, headache, rash and severe joint pain with or without swelling. Pain in the joints is a major feature of Chikungunya symptoms. The ankles and wrists are most commonly affected. Intense pain due to pressure placed on a wrist is commonly used to help diagnose the disease.

Symptoms begin to appear within 2 – 12 days after being infected from the bite of an infected female mosquito. Initial symptoms include a sudden onset of flu-like symptoms including severe headache, chills, insomnia, fever, joint pain, nausea and vomiting. A rash may occur, first as a flush over the face and chest, followed by a rash that can have lesions. There can be mild hemorrhaging in children. Joint pain can persist for many months or even years after the other symptoms have subsided. All but a few patients recover.

How is it transmitted to humans?
The cycle of transmission is from mosquito to human and back to mosquito. Transmission to humans may occur when infected female mosquitoes attempt to feed on a human host. The species of mosquitoes that may transmit the virus are Aedes aegypti (Fig. 1) and Aedes albopictus (Fig. 2). The eggs of these mosquitoes are laid just above the water line in water-holding containers. When the water level rises, the eggs hatch into larvae, where they continue to develop through the pupal stage, then to the adult that will fly to seek a blood meal. During the recent outbreak, a nurse caring for an infected patient in France came down with Chikungunya fever, suggesting that transmission may also occur from person to person, without the involvement of a mosquito vector.

Mosquito Surveillance and Monitoring Section

Effective Mosquito-Control Program

Surveys are essential for the planning, operation and evaluation of an effective mosquito-control program, whether for the prevention of mosquito-borne diseases or to reduce mosquito populations to levels permitting normal activities without undue discomfort. Initial surveys identify the species of mosquitoes present and provide general information on locations, densities and disease potential. With this knowledge it may be possible to determine life cycles and feeding preferences; predict larval habitats, adult resting places and flight ranges; and perhaps even make preliminary recommendations for control programs.

Basic Inspection Program

The next step is to embark on a formal surveillance program in which routine monitoring of mosquito presence is conducted. A basic inspection program usually addresses adult and larval population density and species composition, rainfall and tide monitoring, and breeding site locations. Additional specialized surveillance may be conducted to detect arboviral presence in birds and mosquito populations, operation of ovitraps (e.g., for Ae. aegypti and Ae. albopictus surveillance), or sampling of floodwater mosquito eggs to locate breeding sites. This information not only provides justification for source reduction and insecticide applications, but it also serves as an ongoing indicator of the effectiveness of these activities and continually adds to the database of knowledge concerning mosquitoes in the area. Such inspections do not determine the absolute population of mosquitoes, but they can show fluctuations in relative mosquito abundance and diversity over time in the various habitats visited.

Mosquito Mapping

Reasonably accurate and comprehensive maps are essential in conducting a mosquito-control operation. Maps provide information for field survey and control activities, program evaluation, and reporting and budgeting purposes. They show elevations, streets, roads and railroads, as well as ponds, lakes, streams, sewage lagoons, flooded woodlots and other breeding areas. They are used for orientation and for locating and plotting larval breeding places and adult sampling stations.

When large areas are involved, a master map may be needed for planning drainage and other field operations. The master map will indicate the treatment areas, the possible flight range of mosquitoes from breeding sites and the potential degree of penetration into populated areas. Larval and adult sampling stations can be indicated by symbols and numbers. Counts made at these stations at weekly or biweekly intervals provide information for current evaluation of the mosquito problem at any time by indicating the abundance of mosquitoes, species involved, flight range and habitat, and disease potential. This information identifies areas requiring high priority for treatment.

Narrative descriptions, sometimes necessary for exact location description, are simplified whenever possible. For example, "N.W. corner of 15th Street and Ninth Avenue" is a brief description that leaves no doubt as to the location. There may be some areas that are difficult to accurately locate (e.g., marshlands). However, maps can be subdivided into numbered or named areas for easy reference, and Global Positioning System (GPS) coordinates are very reliable. Some common methods of subdividing maps involve the use of geographical features, artificial grids or a combination of both to set boundaries on areas that are indexed for easy reference and filing. To avoid cluttering, the larger areas may be further subdivided by the use of transparent overlays, again employing geographical features or a grid. Once the area of inspection is delineated by reference to index numbers, additional location data can be conveyed clearly by the use of cards that include a rough sketch of the area or incorporated into a Geographic Information System (GIS) format.

Mosquito Record-keeping

In order to avoid comparing dissimilar parameters, inspections should be consistent both in method and location. Keeping clear, accurate records is as important as the data gathering itself. Surveillance records are managed in a manner that ensures subsequent inspections can be conducted in a similar manner by others less familiar with the area. They usually include the inspector's name, date of inspection and exact location in addition to the data collected. Data-recording forms and devices promote uniformity, which makes records easier to read, interpret and summarize, and serve as a reminder to the inspector to record all pertinent information. In the absence of data recorders, standardized formats lead to more consistently accurate transcription of the data into the permanent records.

Mosquito Egg Surveys

Egg surveys are carried out primarily to determine the exact breeding locations of mosquitoes. Aedes, Ochlerotatus and Psorophora mosquitoes lay their eggs on damp soil in places subject to intermittent flooding. Two types of egg surveys may be conducted for these genera: sod sampling and egg separation.

Sod Sampling

Sod samples, usually containing 8 cubic inches of soil and vegetation with a thickness of about an inch, are stored for a week or more to allow the embryos time to develop within the eggs. The sod samples are then placed in glass jars and flooded with water. The larvae are identified after they hatch. Several sequential floodings and dryings might be necessary to get sufficient cumulative hatch. In larval surveys, sod sampling delineates breeding areas, especially when sampling is done during times when larvae are not present.

Egg Separation

Egg separation machines can be used for separating mosquito eggs from soil and debris by mechanical agitation, washing, screening, or sedimentation of debris and flotation of the eggs in a saturated salt solution. Sod or soil samples are cut in the field with a sharp trowel around a 6-inch-square template, placed in plastic bags and stored (sometimes for months) in a cool room. The various species and densities of Aedes, Ochlerotatus and Psorophora can be identified by microscopic examination of live or preserved eggs using taxonomic keys for mosquito eggs.

Oviposition Trap

Collections of mosquito eggs in oviposition traps are used to detect and monitor container-breeding mosquitoes such as Oc. triseriatus, Ae. aegypti and Ae. albopictus. The oviposition trap can easily be made out of food cans (3-pound coffee cans) or pint jars painted black inside and outside. The traps are placed in shaded areas at a height no greater than 1.2 m and filled with water and a few dried leaves placed at the bottom of the container. An oviposition substrate made of a strip of various materials (seed germination paper, muslin, formica, balsa wood, wooden tongue depressor, etc.) is then placed vertically inside the container with the water covering about half of it.

Gravid females use this substrate to lay eggs just above the water level. Traps are checked every 10 to 14 days to prevent them from becoming breeding sources. If larvae are found in the trap, then the water should be dumped and the trap reset. The ovipositional substrate is periodically collected and returned to the laboratory in a plastic bag. Samples are kept cool and moist during transportation, taking care to avoid too much moisture, which could cause eggs to begin hatching. Eggs or the resulting 4th instar larvae are then identified.

Larval and Pupal Surveillance
Before beginning a survey, obtain information about the general breeding behavior and habitats of the species known or suspected to be in the area. An experienced person may be able to spot the probable mosquito breeding places in a specific area by rapid reconnaissance. These areas are carefully numbered and marked on the map. Determining the specific breeding sites and establishing permanent larval sampling stations requires a more detailed inspection. Larval surveys to determine the exact areas in which the mosquitoes breed and their relative abundance are of special value in control operations.

Equipment
A white enameled or plastic dipper about 4 inches in diameter (1 pint or 350 ml capacity) is frequently used for collecting mosquito larvae. The handle of the dipper may be lengthened by inserting a suitable piece of wood dowel or PVC pipe. Specially designed dippers can be created so that their capacity can be directly related to the amount of water surface examined. Thus, the number of larvae per square foot or meter can be computed with reasonable accuracy.

Dip Procedure
Mosquito larvae of some species are usually found near surface vegetation or debris. In larger ponds or bodies of water, these larvae are ordinarily confined to the shoreline areas where it is necessary to proceed slowly and carefully in searching for mosquito larvae as disturbance of the water or shadows may cause the larvae to dive to the bottom.

Anopheline larvae are collected by a skimming movement of the dipper with one side pressed just below the surface. The stroke is ended just before the dipper is full because larvae will be lost if the dipper is filled to the point that it runs over. Where clumps of erect vegetation are present, it is best to press the dipper into a clump with one edge depressed so that the water flows from the vegetation into the dipper. Culicine larvae such as Ae. vexans or Oc. sollicitans or species of Psorophora require a quicker chopping motion of the dipper as they are more likely to dive below the surface when disturbed.

The inspector records the number of dips made and the number of larvae found, by instar if warranted, and transfers representative sample specimens by pipette into small vials of alcohol for later identification. With most species, it is possible to get a rough idea of the breeding activity by computing the average number of larvae of each species per dip. The number of dips required will depend on the size of the area and the relative larval density, but for convenience is often in multiples of 10. Inspection should be made at weekly or biweekly intervals during the mosquito breeding season, as areas that are entirely negative at one time may rapidly become heavily infested.

Inspections for certain species require variations in the procedure described above. For example,

Coquillettidia larvae remain below the surface throughout much of their development attached by the siphon to the stems of emergent vegetation. These larvae are found by pulling up aquatic plants (cattail, sedges, pickerelweed, etc.), washing or shaking them in a pan of water, and searching the bottom muck and debris.

Inspection for Oc. triseriatus, Oc. sierrensis, etc., breeding involves searching tree holes and artificial containers such as tires. These containers are often too small for an ordinary dipper, but water can be transferred with a turkey baster or siphoned into a dipper or pan where the larvae can be seen.

Mosquito traps recreate warm moist CO_2 (human breath), primarily with dry ice but other traps use propane, and some traps add the irresistible attraction of octenol to trap mosquitoes. Some traps will contain a suction fan and a light bulb to trap and attract the female mosquito. Several mosquito traps will operate quietly and will eliminate hundreds of mosquitoes in a few hours at dusk and dawn.

Several government agencies will place the daily quarry of mosquitoes into plastic bags for counting and determining the mosquito species. The captured mosquitoes are often sent to a laboratory for further analysis.

Mosquito Control Section Summary

Mission of the Environmental Protection Agency
The mission of the Environmental Protection Agency (**EPA**) is to protect human health and the environment. The EPA reviews and approves pesticides and their labeling to ensure that the pesticides used to protect public health are applied by methods which minimize the risk of human exposure and adverse health and environmental effects.

In relation to mosquito control, the Agency (**EPA**) also serves as a source of information about pesticide and non-pesticide controls to address the concerns of the general public, news media, and the state and local agencies dealing with outbreaks of infectious diseases or heavy infestations of mosquitoes. The following sections provide some basic information on mosquito control, safety precautions, and information on insecticides used for mosquito control programs.

How Are Mosquitoes Controlled with Pesticides and Other Methods?
The first step in mosquito control is surveillance. Mosquito specialists conduct surveillance for diseases harbored by domestic and nonnative birds, including sentinel chickens (used as virus transmission indicators), and mosquitoes. Surveillance for larval habitats is conducted by using maps and aerial photographs, and by evaluating larval populations.

Other techniques include various light traps, biting counts, and analysis of reports from the public. Mosquito control programs also put high priority on trying to prevent a large population of adult mosquitoes from developing, so that additional controls may not be necessary.

Since mosquitoes must have water to breed, methods of prevention may include controlling water levels in lakes, marshes, ditches, or other mosquito breeding sites, eliminating small breeding sites if possible, and stocking bodies of water with fish species that feed on larvae.

Both chemical and biological measures may be employed to kill immature mosquitoes during larval stages. *Larvicides* target larvae in the breeding habitat before they can mature into adult mosquitoes and disperse.

Larvicides
Larvicides include the bacterial insecticides *Bacillus thuringiensis israelensi*s and *Bacillus sphaericus*, the insect growth inhibitor methoprene, and the organophosphate insecticide temephos. Mineral oils and other materials form a thin film on the surface of the water, which cause larvae and pupae to drown.

Liquid larvicide products are applied directly to water using backpack sprayers and truck or aircraft-mounted sprayers. Tablet, pellet, granular, and briquette formulations of larvicides are also applied by mosquito controllers to breeding areas.

Homeowners may apply Mosquito Dunks (made with Bacillus thuringiensis Berliner var. israelensis or B.t.i.) to kill mosquito larvae in the water. This natural ingredient is harmless to other living things and is biodegradable. (Summit Chemical Co. 800-227-8664.)

Always follow the pesticide label's instructions.

Methoprene (Altosid XR)
Methoprene (Altosid XR) is another safe material for control of mosquito larvae. It is an insect hormone that retards the development of larvae (disrupts molting) and prevents mosquitoes from developing into adults (Clarke Mosquito Control Products, Inc. 800-323 -5727).

Altosid XR Briquettes
Altosid XR Briquettes can be placed even on ice for season-long control. Treat swamps, ponds, and marsh areas in early spring before thawing. These extended-release briquettes will provide up to 150 days of uninterrupted mosquito control once they hit the water. They can be applied by hand and the product is labeled for use in known fish habitats.

Microbial Insecticides
The product known as **Bti** (*Bacillus thuringiensis israeliensis*) can be as effective as chemical insecticides. When the bacteria Bti encysts, it produces a protein crystal toxic to mosquito and midge larvae. Once the bacteria has been ingested, the toxin disrupts the lining of the larvae's intestine. It has no effect on a vast array of other aquatic organisms except midges in the same habitat. Bti strains are sold under the names Bactimos, Teknar and Vectobac.

Mosquito Dunks or Briquettes
Product Description: Small donut shaped and sized objects that release bacteria into water where mosquitoes are breeding. When the larvae feed on the bacteria, they die.

Target Pests: Mosquito larvae.

Areas of Use: *Anywhere*. This bacteria will not hurt pets, children, birds, or wildlife. Great for use in bird baths, ponds, lakes, swamps, rain barrels, clogged gutters, sewers that hold water, retention ponds, drainage ditches, slow moving streams, bottoms of planters and anywhere water is able to accumulate and provide mosquitoes a place to reproduce. Always follow the pesticide label's instructions.

Application: One dunk will cover about 100 sq/ft of surface area. You can break it up if treating small areas and tie it to a weight or anchor of some sort when applying it to moving water. Always follow the pesticide label's instructions.

Juvenile Hormone
Methoprene (sold under the name Altosid) is an insect growth regulator widely used by abatement districts to control mosquito larvae. Methoprene mimics a natural juvenile hormone, and when present in the larval habitat, it keeps immature insects from maturing into adults. Unable to metamorphose, the mosquitoes die in the pupal stage.

Vector control technicians sometimes use methoprene to reach larval sources that would otherwise be difficult or dangerous to treat. Pellets can be flushed down toilets into underground septic tanks known to be breeding house mosquitoes. The methoprene kills the mosquitoes without upsetting the septic system's bacterial digestive processes.

Larvicidal Oils
Oils have been used for mosquito control for more than a century. The Marin / Sonoma District in California uses Golden Bear 1111, a light-viscosity oil that spreads quickly and evenly over the water surface, preventing larvae and pupae from obtaining oxygen through the surface film.

Oils have always been used as a product of last resort for the control of mosquito pupae, since this stage does not feed but does require oxygen. The only other option would be draining the source. Closer surveillance and timing of other agents and techniques can greatly reduce the need for larvicidal oils. Always follow the pesticide label’s instructions.

Chemical Larvicides
Costs and complexity of mosquito control have increased markedly since the passage of the Environmental Protection Act in 1969. The increasing number of governmental regulations and permitting bodies, rising costs of alternative chemicals, and the spreading resistance of many vector species to existing pesticides have almost completely changed or eliminated the use of chemical control agents.

Chlorinated hydrocarbons like DDT and Chlordane are very much a thing of the past, as are the use of organophosphate and carbamate insecticides. Chlorinated hydrocarbons were removed from the US market in 1964, and in 1987.

Adulticides
Adult mosquito control may be undertaken to combat an outbreak of mosquito-borne disease or a very heavy nuisance infestation of mosquitoes in a community. Pesticides registered for this use are *adulticides* and are applied either by aircraft or on the ground, employing truck-mounted sprayers. State and local agencies commonly use the organophosphate insecticides Malathion and Naled and the synthetic pyrethroid insecticides Permethrin, Resmethrin, and Sumithrin for adult mosquito control. Always follow the pesticide label’s instructions.

Mosquito adulticides are applied as ultra-low volume (**ULV**) sprays. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill flying mosquitoes on contact. ULV applications involve small quantities of pesticide active ingredient in relation to the size of the area treated, typically less than 3 ounces per acre, which minimizes exposure and risks to people and the environment.

Chemical Control of Adult Mosquitoes
Because of environmental concerns and drift, chemical pesticides are not the most popular method. But if you do use chemical pesticides, the technique used for adult mosquito control is known as ultra-low volume (**ULV**) spray. A small quantity of the pesticide is atomized into micron-size particles and broadcast in a fog that drifts into sites where the adult mosquitoes hide. At best, control is achieved up to 300 feet away, but it does help reduce the numbers of biting mosquitoes to tolerable levels. In recent years the use of vehicle-mounted units has decreased in favor of small, hand-carried dispersal units. This allows a more precise application of the pesticide.

The pesticide used for ULV spraying is pyrethrum (sold as Pyrocide), a naturally occurring substance harvested from two species of Old World chrysanthemums, or pyrethrum flowers. This material is the least toxic available for mosquito control, and it degrades into non-toxic by-products within 4 to 6 hours after spraying.

Indoor Control
Space sprays or aerosol ***"bombs,"*** containing synergized pyrethrins 0.1%, are effective against adult mosquitoes. Frequent treatments may be needed during problem periods.

Agricultural Pesticide Section

All agricultural employers whose workers perform hand labor operations in fields, forests, nurseries, and greenhouses treated with pesticides, and handle pesticides in these locations are covered by the U.S. Environmental Protection Agency's worker protection standard revised 2005.

Agricultural employers must be in full compliance with this regulation before April 15, 1994. Additionally, owners, operators, and their immediate family members must comply with some of the provisions of this standard. This supplement to *"A Summary of Federal Laws and Regulations Affecting Agricultural Employers,"* summarizes this regulation.

Agricultural employers must be in full compliance with the U.S. Environmental Protection Agency's (**EPA**) 2005 worker protection standard. This standard, which became effective on October 20, 1992, revises EPA's 1974 worker protection standard. Precise estimates of the number of workers and handlers who will be covered by the WPS are unknown, but the EPA estimates that nearly 4 million owners, operators, family members, hired workers and handlers could be affected.

The WPS covers every agricultural employer, including livestock producers, who have employees that perform hand labor operations in fields, forests, nurseries, and greenhouses treated with pesticides.

Unlike other laws and regulations affecting agricultural labor, the WPS does not exempt any employment in commercial agriculture involving hand labor in fields, but owners or operators and immediate family members are specifically exempt from some provisions.

The WPS expands coverage to include more employees and expands employers' requirements for training employees who handle pesticides, protecting employees from pesticide exposure, and providing emergency assistance to exposed employees. Although many laws affecting agricultural employment exempt farming enterprises that employ small numbers of hired farmworkers, the new standard has no exemptions based on the number of employees.

Employers covered by the WPS must:
Reduce overall exposure to pesticides by prohibiting handlers from exposing workers during pesticide application, excluding workers from areas being treated and areas under a restricted entry interval, and notifying workers about treated areas. Some activities are allowed during restricted entry intervals if workers are properly trained and protected.

Mitigate exposures by requiring decontamination supplies be present and emergency assistance be available.

Inform workers about pesticide hazards by requiring safety training (workers and handlers), safety posters, access to labeling information, and access to specific information (listing of treated areas on the establishment).

WPS provisions are very complicated and are likely to affect a large number of employers and their workers. States may also issue worker protection standards that are stricter than the WPS. Therefore, employers should contact their State agency that regulates the

Federal Insecticide, Fungicide, and Rodenticide Act in cooperation with the EPA to determine whether they must comply with the WPS and local regulations. Nothing in this report replaces technical and professional legal advice.

Background
The Federal Insecticide, Fungicide, and Rodenticide Act (**FIFRA**) of 1947, as amended, sets an overall risk/benefit standard for pesticide registration, requiring that all pesticides perform their intended function, when used according to labeling directions, without imposing unreasonable risks of adverse effects on human health or the environment (Runyan, 1992).

During the congressional discussion of FIFRA amendments in 1972, the Senate Committee on Agriculture and Forestry (Committee) "*found protection of man and the environment to be a broad term encompassing farmers, farmworkers, and others who come into contact with pesticides...*" (57 FR 38102).

The Committee further found "that the bill [The Federal Environmental Pesticide Control Act of 1972 (FEPCA)] requires the Administrator to require that the labeling and classification of pesticides be such as to protect farmers, farmworkers, and others coming in contact with pesticides or pesticide residues" (57 FR 38102).

Given the above mandate, the EPA issued regulations in 1974 dealing with pesticide-related occupational safety and health of workers performing hand labor operations in fields during and after application of pesticides (40 CFR).

Four Basic Requirements
These regulations contained four basic requirements:
(1) workers are not to be sprayed with pesticides;
(2) there are specific restricted entry intervals (REI) for 12 pesticides, interim restrictive entry levels for certain pesticides, and a general re-entry interval for all other agricultural pesticides prohibiting re-entry into treated areas until sprays have dried, dusts have settled, and vapors have dispersed;
(3) protective clothing is required for any worker entering a treated area before the specific re-entry period has expired; and
(4) "appropriate and timely" warnings are required for re-entry. These warnings may be given orally in appropriate language, placed on the pesticide notice board, or posted in the field.

1974 Regulations
The EPA determined that the 1974 regulations did not adequately protect agricultural workers and pesticide handlers who were occupationally exposed to pesticides. In order to correct these inadequacies, the EPA issued new regulations designed to reduce exposure to pesticides, mitigate exposure, and inform workers about pesticides. Reducing overall exposure to pesticides will be accomplished by prohibiting handlers from exposing workers during application, excluding workers from areas being treated and areas under a REI (some activities are allowed during a REI if workers are properly trained and protected), and notifying workers about treated areas.

Mitigating Exposures
Mitigating exposures will be accomplished by requiring decontamination supplies and emergency assistance. Workers will be informed about pesticide hazards through required safety training (workers and handlers), safety posters, access to labeling information, and access to specific information (listing of treated areas on the establishment).

Worker Protection Standard for Agricultural Pesticides
Provisions of the WPS apply to:

Owners or managers of farms, forests, nurseries, or greenhouses where pesticides are used in the production of agricultural plants.

Those who hire or contract for services of agricultural workers to do tasks related to the production of agricultural plants on a farm, forest, nursery, or greenhouse.

General Duties of WPS

The general duties of the WPS require an agricultural employer or a pesticide handler-employer to:

- Assure that each worker and handler subject to the standard receives the required protections.

- Assure that any pesticide subject to the standard is used in a manner consistent with the labeling of the pesticide, including the requirements in the standard.

- Provide sufficient information and directions to each person who supervises any worker or handler to assure that each worker or handler receives the required protection. The information and directions must specify which persons are responsible for actions required to comply with the standard.

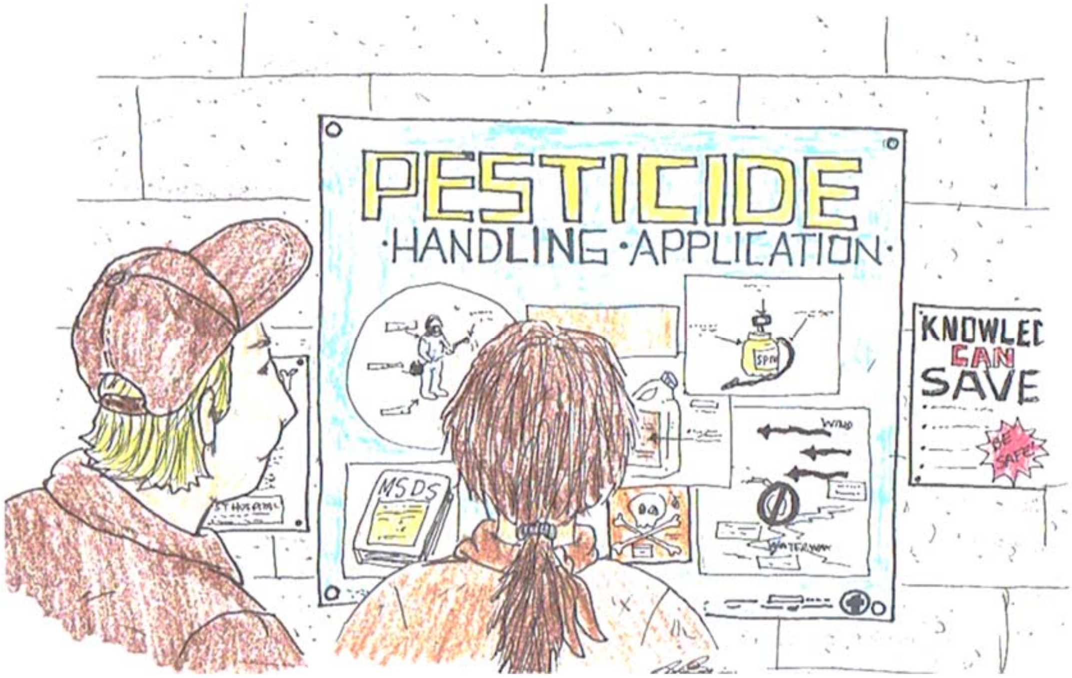
- Require each person who supervises any worker or handler to assure compliance by the worker or handler with the provisions of this standard and to assure that the worker or handler receives the required protection (40 CFR).

- The general duties also prohibit agricultural and handler employers from taking any retaliatory actions against workers attempting to comply with this standard, or from taking any action that prevents or discourages any worker or handler from complying or attempting to comply with the WPS.

Labeling
Requires everyone applying pesticides to obey instructions printed on the pesticide container's label.

Always wear your bee suit even while inspecting the hive. Most applicators are stung during their inspection. Numerous insecticides are approved for use on bees. These chemicals are very effective when used properly. Soapy water doesn't work effectively on a colony because honeycomb prevents adequate coverage. Bee colonies may be removed physically by hand or by vacuuming with special types of vacuums. Once collected, the bees can be placed in a hive, released at a different location, or killed with insecticide. The bulb seems to be the best at killing bees and wasps, but beware, they will go after you and it takes a couple of years to get over the fear of the entire hive attacking you.

Worker Protection Standard Section



Summary of WPS Requirements

Protection during applications -- Applicators are prohibited from applying a pesticide in a way that will expose workers or other persons. Workers are excluded from areas while pesticides are being applied.
Restricted-entry intervals -- Restricted-entry intervals must be specified on all agricultural plant pesticide product labels. Workers are excluded from entering a pesticide-treated area during the restricted-entry interval, with only narrow exceptions.
Personal protective equipment -- Personal protective equipment must be provided and maintained for handlers and early-entry workers.
Notification to workers -- Workers must be notified about treated areas so they may avoid inadvertent exposures.
Decontamination supplies -- Handlers and workers must have an ample supply of water, soap, and towels for routine washing and emergency decontamination.
Emergency assistance -- Transportation must be made available to a medical care facility if a worker or handler may have been poisoned or injured. Information must be provided about the pesticide to which the person may have been exposed.
Pesticide safety training and safety posters -- Training is required for all workers and handlers, and a pesticide safety poster must be displayed.
Access to labeling and site-specific information -- Handlers and workers must be informed of pesticide label requirements. Central posting of recent pesticide applications is required.

"**Agricultural Use Requirements** - Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment, notification of workers, and restricted entry intervals."
Pesticides used on sod farms are covered by WPS.

Some pesticide uses are not covered by WPS, even when the Agricultural Use Requirements section is on the labeling. For example, if the pesticide labeling bears an Agricultural Use Requirements section, but the product also can be applied to rights-of-way, the rights-of-way use is not covered by WPS.

WPS Requires Restricted Entry to Treated Areas
Restricted-entry interval (**REI**) is the time immediately after a pesticide application when entry into the treated area is prohibited or very limited. REIs are established for all pesticides used in the production of agricultural plants depending on toxicity. The REI is listed on the pesticide labeling under the heading "Agricultural Use Requirements" in the "Directions for Use" section of the pesticide labeling or next to the crop or application method to which it applies.

REIs must be specified on all agricultural plant pesticide product labels. Workers are excluded from entering a pesticide treated area during the REI, with few narrow exceptions. The duration of REIs ranges from 4 hours to several days. Some pesticides have one REI, such as 12 hours, for all crops and uses. Other products have different REIs, depending on the crop or method of application. When two or more pesticides are applied at the same time and have different REIs, the longer interval must be followed.

There is a no-entry period for 4 hours for all products with WPS labeling; this means no early entry.

WPS Requires Notification of Applications
Employers must notify workers about pesticide applications on the agricultural establishment if they will be on or within a quarter (1/4) mile of the treated area. In most cases, employers may choose between oral warnings or posted warning signs, but they must tell workers which warning method is in effect. All applications must be additionally recorded and displayed at the central location.

Most products allow worker notification either orally or by posting a field warning sign, one or the other is acceptable as long as workers are informed of which method is being used. However, you must provide double notification if the pesticide label has this statement in the “Directions for Use” section under the heading “Agricultural Use Requirements”:

“Notify workers of the application by warning them orally AND by posting warning signs at entrances to treated areas.”
If double notification is specified on the pesticide label workers must be orally notified about REIs and treated fields must be physically posted with warning signs during the REI. It is the agricultural establishment’s responsibility to post warning signs in the field if it is required. Farms employing ONLY immediate family members are not required to post the field.

Signs must have the words “**Danger-Peligro**” and “**Pesticides-Pesticidas**” at the top and “Keep Out-No Entre” at the bottom. Signs must be at least 14” x 16”, with a minimum letter height of one inch. The Spanish portion of the sign may be replaced with a substitute language read by the majority of non-English speaking workers. In greenhouses and nurseries, smaller signs (4.5” x 5”) are acceptable.

Warning signs must be:
- Posted 24 hours or less before application
- Removed within three (3) days after the end of the REI
- Posted so they can be seen at all normal entrances to treated areas, including borders adjacent to labor camps
- If no employees were involved with treatment, or the employees do not come within a quarter (1/4) mile, no posting is required

Oral warnings must be delivered in a manner understood by workers, using an interpreter if necessary. Oral warnings must contain the following information:
- Location and description of the treated area
- The length of the REI
- Specific directions not to enter during the REI

WPS Requires That Specific Information Regarding Applications and Safety Be Posted at a Central Location
The WPS requirement that information be posted (displayed) at a central location is cited by the EPA as one of the most commonly violated provisions.

WHAT IS THE WORKER PROTECTION STANDARD?

The Worker Protection Standard (WPS) is a regulation issued by the U.S. Environmental Protection Agency. It covers pesticides that are used in the production of agricultural plants on farms, forests, nurseries, and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use such pesticides, or
(2) employ workers or pesticide handlers who are exposed to such pesticides.
If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide to your employees and, in some cases, to yourself and to others:

- information about exposure to pesticides,
- protections against exposures to pesticides, and
- ways to mitigate exposures to pesticides.

INFORMATION
To ensure that employees will be informed about exposure to pesticides, the WPS requires:

- **Pesticide safety training** — for workers and handlers,
- **Pesticide safety poster** — to be displayed for workers and handlers,
- **Access to labeling information** — for pesticide handlers and early-entry workers, and
- **Access to specific information** — centrally located application information of pesticide treatments on the establishment.

PROTECTION
To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- **prohibit handlers from applying a pesticide in a way that will expose workers or other persons**,
- **exclude workers from areas being treated** with pesticides,
- **exclude workers from areas that remain under a restricted-entry interval (REI)**, with narrow exceptions.
- **protect early-entry workers** who are doing permitted tasks in treated areas during an REI, including special instructions and duties related to correct use of PPE,
- **notify workers** about treated areas so they can avoid inadvertent exposures, and
- **protect handlers during handling tasks**, including monitoring while handling highly toxic pesticides, and duties related to correct use of PPE.

These key terms have very specific meanings in the WPS. Note that these definitions may be different from definitions found in other state and federal laws and regulations.

MITIGATION

To mitigate pesticide exposures that employees receive, the WPS requires:

• **Decontamination supplies** — providing handlers and workers an ample supply of water, soap, and towels for routine washing and emergency decontamination.

• **Emergency assistance** — making transportation available to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide, and providing information about the pesticide(s) to which the person may have been exposed.

These key terms have very specific meanings in the WPS. Note that these definitions may be different from definitions found in other state and federal laws and regulations.

Terms You Need to Know

These definitions will help you determine whether you are affected by the Worker Protection Standard. *These key terms have very specific meanings in the WPS. Note that these definitions may be different from definitions found in other state and federal laws and regulations.*

Agricultural plants: Plants grown or maintained for commercial or research purposes. Examples: food, feed, and fiber plants, trees, turfgrass, flowers, shrubs, ornamentals, and seedlings.

Farms: Operations, other than nurseries or forests, that produce agricultural plants outdoors.

Forests: Operations that produce agricultural plants outdoors for wood fiber or timber products.

Greenhouses: Operations that produce agricultural plants indoors in an area that is enclosed with nonporous covering and that is large enough to allow a person to enter. Examples: polyhouses, mushroom houses and caves, and rhubarb houses, as well as traditional greenhouses. Malls, atriums, conservatories, arboretums, and office buildings that grow or maintain plants primarily for decorative or environmental benefits are **not** included.

Nurseries: Operations that produce agricultural plants outdoors for:

• transplants to another location, or
• flower or fern cuttings.

Examples: flowering and foliage plants or trees; tree seedlings; live Christmas trees; vegetable, fruit, and ornamental transplants; and turfgrass produced for sod.

DOES THE WORKER PROTECTION STANDARD APPLY TO YOU?

You need the information in this section if:
• You own or manage a farm, forest, nursery, or greenhouse where pesticides are used in the production of agricultural plants.

Even if you are the owner of the farm, forest, nursery, or greenhouse and you or members of your family do all the work there, you are a "WPS employer." You must comply with ***some*** of the requirements described in this manual, such as restricted-entry intervals and personal protective equipment, and ***all*** the specific requirements listed in the pesticide labeling. See Agricultural Owner Exemptions, for more information.

• You hire or contract for the services of agricultural workers to do tasks related to the production of agricultural plants on a farm, forest, nursery, or greenhouse. This includes labor contractors and others who contract with growers to supply agricultural laborers.

• You operate a business in which you (or people you employ) apply pesticides that are used for the production of agricultural plants on any farm, forest, nursery, or greenhouse.

Commercial pesticide handlers and their employees are included with respect to such pesticides even if the pesticide handling task (mixing, loading, disposal, etc.) takes place somewhere other than the farm, forest, nursery, or greenhouse — at the commercial handling establishment or an airport hangar, for example.

• You operate a business in which you (or people you employ) perform tasks as a crop advisor on any farm, forest, nursery, or greenhouse.

"Crop advisor" means any person who is assessing pest numbers or damage, pesticide distribution, or the status, condition, or requirements of agricultural plants. Examples include crop consultants and scouts.

If you are in any of these categories, you must comply with the Environmental Protection Agency's Worker Protection Standard (40 CFR, part 170) including all revisions through 2004.

Under the WPS, you may be both a worker and an employer of workers.

Under the WPS, you may be both a handler and an employer of handlers.

WHO DOES THE WPS PROTECT?

The WPS requires employers to take steps to protect two types of agricultural employees: **workers** and **pesticide handlers**. The terms “worker” and “pesticide handler” are defined very specifically in the WPS, and employers of persons who meet these definitions must comply with the WPS. Depending on the tasks being performed, you may need to provide the same employee with worker protections on some occasions and pesticide handler protections on other occasions.

Owners of agricultural establishments and members of their immediate family are exempt from many WPS requirements.

WORKERS

A worker is anyone who: (1) is employed (including self-employed) for any type of compensation and (2) is doing tasks, such as harvesting, weeding, or watering, relating to the production of agricultural plants on a farm, forest, nursery, or greenhouse. This term does ***not*** include persons who are employed by a commercial establishment to perform tasks as crop advisors.

PESTICIDE HANDLERS

A pesticide handler is anyone who: (1) is employed (including self-employed) for any type of compensation by an agricultural establishment or a commercial pesticide handling establishment that uses pesticides in the production of agricultural plants on a farm, forest, nursery, or greenhouse, and (2) is doing any of the following tasks:

- mixing, loading, transferring, or applying pesticides,
- handling opened containers of pesticides,
- acting as a flagger,
- cleaning, handling, adjusting, or repairing the parts of mixing, loading, or application equipment that may contain pesticide residues,
- assisting with the application of pesticides, including incorporating the pesticide into the soil after the application has occurred,
- entering a greenhouse or other enclosed area after application and before the inhalation exposure level listed on the product labeling has been reached or one of the WPS ventilation criteria have been met to: – operate ventilation equipment, – adjust or remove coverings, such as tarps, used in fumigation, or – check air concentration levels,
- entering a treated area outdoors after application of any soil fumigant to adjust or remove soil coverings, such as tarpaulins,
- performing tasks as a crop advisor: – during any pesticide application, – before any inhalation exposure level or ventilation criteria listed in the labeling has been reached or one of the WPS ventilation criteria has been met, – during any restricted-entry interval,
- disposing of pesticides or pesticide containers.

NOT A HANDLER
A person is ***not*** a handler if he or she only handles pesticide containers that have been emptied or cleaned according to instructions on pesticide product labeling or, if the labeling has no such instructions, have been triple-rinsed or cleaned by an equivalent method, such as pressure rinsing.

A person is ***not*** a handler if he or she (1) is ***only*** handling pesticide containers that are unopened ***and*** (2) is ***not***, at the same time, also doing any handling task (such as mixing or loading).

- You are ***not*** a handler if you:
    - purchase pesticides and transport them unopened to an establishment.
    - carry unopened containers into a pesticide storage facility.
    - transport unopened containers to the site where they are to be mixed, loaded, or applied.

You ***are*** a handler if you are loading unopened water-soluble packets into a mixing tank (because you are mixing and loading the pesticide).

HE HASN'T BEEN THE SAME SINCE THE "RAID" !!!!!!

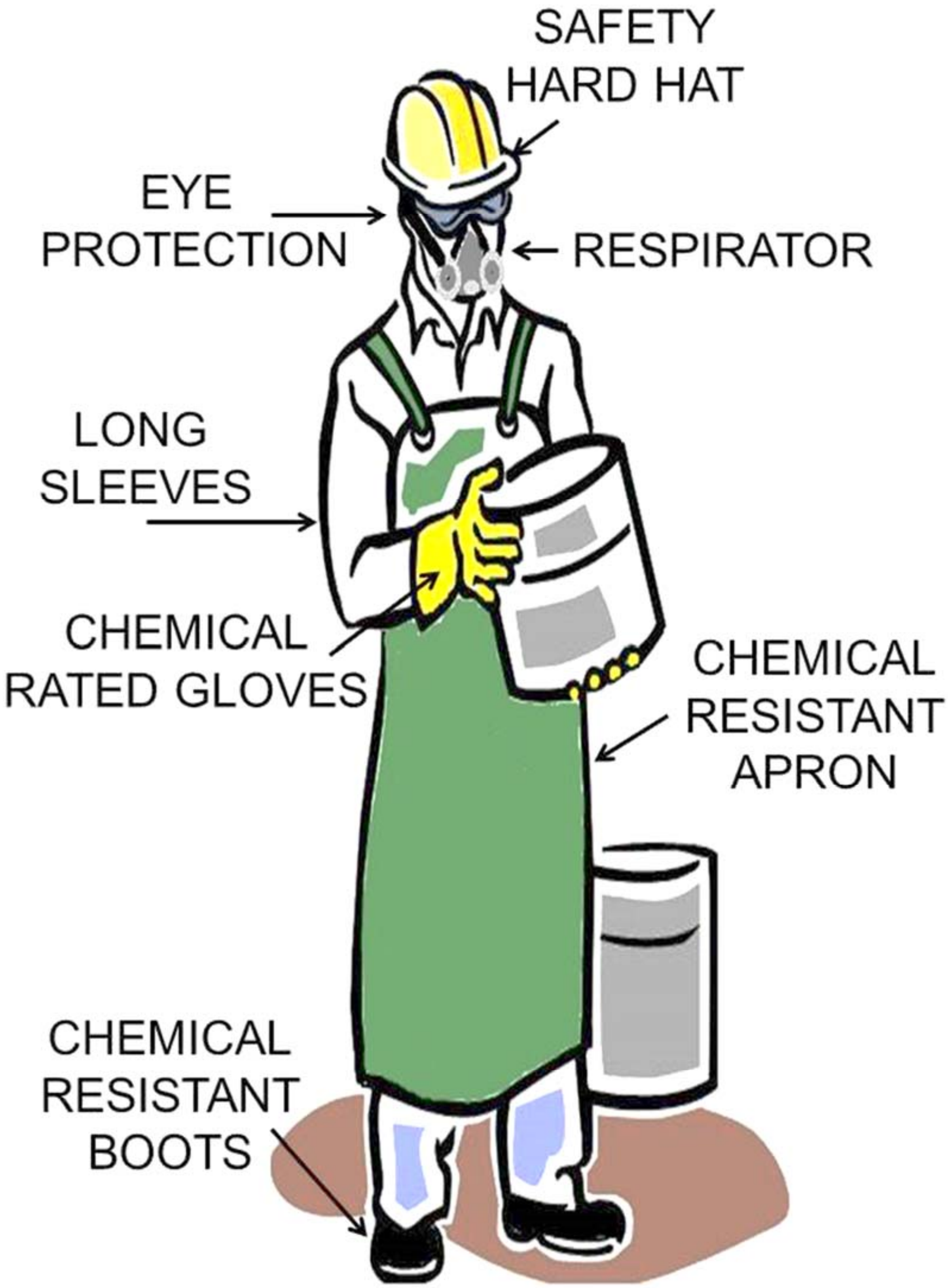

SAFETY
HARD HAT
EYE
PROTECTION
RESPIRATOR
LONG
SLEEVES
CHEMICAL
RATED GLOVES
CHEMICAL
RESISTANT
APRON
CHEMICAL
RESISTANT
BOOTS

Table 1—Entry-Restricted Areas in Nurseries During Pesticide Applications

A. During Application of a Pesticide:	B. Workers are Prohibited in:
(1)(a) Applied:	Treated area plus 100 feet in all directions on the nursery
(i) Aerially, or	
(ii) In an upward direction, or	
(iii) Using a spray pressure greater than 150 psi, or	
(b) Applied as a:	
(i) Fumigant, or	
(ii) Smoke, or	
(iii) Mist, or	
(iv) Fog, or	
(v) Aerosol.	
(2)(a) Applied downward using:	Treated are plus 25 feet in all directions on the nursery
(i) A height of greater than 12 inches from the planting medium, or	
(ii) A fine spray, or	
(iii) A spray pressure greater than 40 psi and less than 150 psi.	
(b) Not as in 1 or 2(a) above but for which a respiratory protection device is required for application by the product labeling.	
(3) Applied otherwise.	Treated area

(c) Greenhouses. (1) When a pesticide application described in column A of Table 2 under paragraph (c)(4) of this section takes place in a greenhouse, the agricultural employer shall not allow or direct any person, other than an appropriately trained and equipped handler, to enter or to remain in the area specified in column B of Table 2 until the time specified in column C of Table 2 has expired.
(2) After the time specified in column C of Table 2 under paragraph (c)(4) of this section has expired, until the expiration of any restricted-entry interval, the agricultural employer shall not allow or direct any worker to enter or to remain in the treated area as specified in column D of Table 2 under paragraph (c)(4) of this section, except as provided in §170.112.
(3) When column C of Table 2 under paragraph (c)(4) of this section specifies that ventilation criteria must be met, ventilation shall continue until the air concentration is measured to be equal to or less than the inhalation exposure level the labeling requires

to be achieved. If no inhalation exposure level is listed on the labeling, ventilation shall continue until after:
(i) Ten air exchanges are completed; or
(ii) Two hours of ventilation using fans or other mechanical ventilating systems; or
(iii) Four hours of ventilation using vents, windows or other passive ventilation; or
(iv) Eleven hours with no ventilation followed by 1 hour of mechanical ventilation; or
(v) Eleven hours with no ventilation followed by 2 hours of passive ventilation; or
(vi) Twenty-four hours with no ventilation.
(4) The following Table 2 applies to paragraphs (c) (1), (2), and (3) of this section.

Table 2—Greenhouse Entry Restrictions Associated With Pesticide Applications

A. When a Pesticide is Applied:	B. Workers are Prohibited in:	C. Until:	D. After the Expiration of Time in Column C Until the Restricted-Entry Interval Expires, the Entry-Restricted Area is:
(1) As a fumigant	Entire greenhouse plus any adjacent structure that cannot be sealed off from the treated area	The ventilation criteria of paragraph (c)(3) of this section are met	No entry restrictions after criteria in column C are met
(2) As a	Entire enclosed area	The ventilation criteria of paragraph (c)(3) of this section are met	Entire enclosed area is the treated area
(i) Smoke, or			
(ii) Mist, or			
(iii) Fog, or			
(iv) Aerosol			
(3) Not in 1 or 2 above, and for which a respiratory protection device is required for application by the product labeling	Entire enclosed area	The ventilation criteria of paragraph (c)(3) of this section are met	Treated area
(4) Not in 1, 2, or 3 above, and:	Treated area plus 25 feet in all directions in the enclosed area	Application is complete	Treated area

(i) From a height of greater than 12 in. from the planting medium, or			
(ii) As a fine spray, or			
(iii) Using a spray pressure greater than 40 psi			
(5) Otherwise	Treated area	Application is complete	Treated area

§ 170.112 Entry restrictions.

(a) General restrictions. (1) After the application of any pesticide on an agricultural establishment, the agricultural employer shall not allow or direct any worker to enter or to remain in the treated area before the restricted-entry interval specified on the pesticide labeling has expired, except as provided in this section.
(2) Entry-restricted areas in greenhouses are specified in column D in table 2 under §170.110(c)(4).
(3) When two or more pesticides are applied at the same time, the restricted-entry interval shall be the longest of the applicable intervals.
(4) The agricultural employer shall assure that any worker who enters a treated area under a restricted-entry interval as permitted by paragraphs (c), (d), and (e) of this section uses the personal protective equipment specified in the product labeling for early-entry workers and follows any other requirements on the pesticide labeling regarding early entry.
(b) Exception for activities with no contact. A worker may enter a treated area during a restricted-entry interval if the agricultural employer assures that both of the following are met:
(1) The worker will have no contact with anything that has been treated with the pesticide to which the restricted-entry interval applies, including, but not limited to, soil, water, air, or surfaces of plants; and
(2) No such entry is allowed until any inhalation exposure level listed in the labeling has been reached or any ventilation criteria established by §170.110(c)(3) or in the labeling have been met.
(c) Exception for short-term activities. A worker may enter a treated area during a restricted-entry interval for short-term activities if the agricultural employer assures that the following requirements are met:
(1) No hand labor activity is performed.
(2) The time in treated areas under a restricted-entry interval for any worker does not exceed 1 hour in any 24-hour period.
(3) No such entry is allowed for the first 4 hours following the end of the application, and no such entry is allowed thereafter until any inhalation exposure level listed in the labeling has been reached or any ventilation criteria established by §170.110(c)(3) or in the labeling have been met.

(4) The personal protective equipment specified on the product labeling for early entry is provided to the worker. Such personal protective equipment shall conform to the following standards:
(i) Personal protective equipment (PPE) means devices and apparel that are worn to protect the body from contact with pesticides or pesticide residues, including, but not limited to, coveralls, chemical-resistant suits, chemical-resistant gloves, chemical-resistant footwear, respiratory protection devices, chemical-resistant aprons, chemical-resistant headgear, and protective eyewear.
(ii) Long-sleeved shirts, short-sleeved shirts, long pants, short pants, shoes, socks, and other items of work clothing are not considered personal protective equipment for the purposes of this section and are not subject to the requirements of this section, although pesticide labeling may require that such work clothing be worn during some activities.
(iii) When “chemical-resistant” personal protective equipment is specified by the product labeling, it shall be made of material that allows no measurable movement of the pesticide being used through the material during use.
(iv) When “waterproof” personal protective equipment is specified by the product labeling, it shall be made of material that allows no measurable movement of water or aqueous solutions through the material during use.
(v) When a “chemical-resistant suit” is specified by the product labeling, it shall be a loose-fitting, one- or two-piece, chemical-resistant garment that covers, at a minimum, the entire body except head, hands, and feet.
(vi) When “coveralls” are specified by the product labeling, they shall be a loose-fitting, one- or two-piece garment, such as a cotton or cotton and polyester coverall, that covers, at a minimum, the entire body except head, hands, and feet. The pesticide product labeling may specify that the coveralls be worn over a layer of clothing. If a chemical-resistant suit is substituted for coveralls, it need not be worn over a layer of clothing.
(vii)(A) Gloves shall be of the type specified on the pesticide product labeling. Gloves made of leather, cotton, or other absorbent materials must not be worn for early-entry activities, unless gloves made of these materials are listed as acceptable for such use on the product labeling. If chemical-resistant gloves with sufficient durability and suppleness are not obtainable, leather gloves may be worn on top of chemical-resistant gloves. However, once leather gloves have been worn for this use, they shall not be worn thereafter for any other purpose, and they shall only be worn over chemical-resistant gloves.
(B) Separable glove liners may be worn beneath chemical-resistant gloves, unless the pesticide product labeling specifically prohibits their use. Separable glove liners are defined as separate glove-like hand coverings made of lightweight material, with or without fingers. Work gloves made from lightweight cotton or poly-type material are considered to be glove liners if worn beneath chemical-resistant gloves. Separable glove liners may not extend outside the chemical-resistant gloves under which they are worn. Chemical-resistant gloves with non-separable absorbent lining materials are prohibited.
(C) If used, separable glove liners must be discarded immediately after a total of no more than 10 hours of use or within 24 hours of when first put on, whichever comes first. The liners must be replaced immediately if directly contacted by pesticide. Used glove liners shall not be reused. Contaminated liners must be disposed of in accordance with any Federal, State, or local regulations.

SPECIAL APPLICATION RESTRICTIONS IN NURSERIES AND GREENHOUSES

The WPS requires additional restrictions during some pesticide applications in nurseries and greenhouses. This part describes those restrictions.

Worker employers must make sure that, during certain nursery applications, **workers and other persons** do not enter treated areas on the nursery or, in some circumstances, do not enter areas that are near the treated area.

SPECIFIC DUTIES Application Restrictions on Nurseries
During any application do not allow or direct any person, other than an appropriately trained and equipped handler, to be in the areas on the nursery. After the application is finished and during the restricted-entry interval:

- keep workers out of the treated area (the area to which the pesticide was directed),
- you may allow workers in the areas just outside the treated area that were off-limits during the application.

Worker employers must make sure that **workers and other persons** do not enter specific areas within the greenhouse during — and, in some instances, after — certain greenhouse applications.

Ventilation Criteria for Greenhouses
1. After some types of pesticide applications listed in column A of Table II, you must make sure that adequate ventilation has occurred before you allow workers to enter the areas specified in column B. If column C indicates that ventilation restrictions apply, **make sure that one of the following ventilation criteria is met**:

- The concentration of the pesticide in the air is measured to be less than or equal to any inhalation exposure level required on the labeling.
- If no inhalation exposure level is listed on the labeling, keep workers out until after: – 10 air exchanges, or – 2 hours of ventilation using fans or other mechanical ventilating systems, or – 4 hours of ventilation using vents, windows or other passive ventilation, or – 11 hours with no ventilation followed by 1 hour of mechanical ventilation, or – 11 hours with no ventilation followed by 2 hours of passive ventilation, or – 24 hours with no ventilation.

2. **After ventilation criteria are met** and until the restricted entry interval expires:

- do not allow workers into the treated area (see Column D on Table II),
- you may allow workers to enter the areas just outside the treated area that were off-limits during the application.

PART C EARLY ENTRY
The WPS allows entry into a treated area that remains under a restricted-entry interval only in a few narrow work situations. When early entry is permitted under the WPS, special protections must be given to the early-entry workers. This subsection describes those work situations and protections.

How to Comply with the Worker Protection Standard for Agricultural Pesticides

What Employers Need To Know

Revised September 2005 Reprinted June 2006

THE IMPORTANCE OF THIS SECTION

Regulatory agencies will enforce the requirements of the federal Worker Protection Standard (Code of Federal Regulations, Title 40, Part 170) when you use a pesticide product with labeling that refers to the Worker Protection Standard. If you do not comply with the Worker Protection Standard requirements, you will be in violation of federal law, since it is illegal to use a pesticide product in a manner inconsistent with its labeling. This manual provides information to help you comply with the requirements of the federal Worker Protection Standard (WPS) for agricultural pesticides, 40 CFR part 170, as published in 1992 and as amended in 1995, 1996, and 2004. EPA may issue additional guidance about the Worker Protection Standard and the Worker Protection Standard may be amended in the future. Check with your state or tribal agency responsible for pesticides for further information and updates.

This 2005 updated *Worker Protection Standard for Agricultural Pesticides — How To Comply Manual*, EPA 735-B-05-002 supersedes the 1993 version, EPA 735-B-93-001. Changes to the Worker Protection Standard have made the 1993 version obsolete and its continued use may lead an employer to be out of compliance with this regulation.

Additional Worker Protection Requirements in Your Area

Some states, tribes, or local governments with jurisdiction over pesticide enforcement may have additional worker protection requirements beyond the requirements described in the federal manual. Check with these agencies to obtain the information you need to comply with all applicable state, tribal, or local requirements.

Material Appended to the Manual

States, tribes, or local governments with jurisdiction over pesticide enforcement may elect to append additional worker protection requirements to the federal manual. These additions may only be appended at the end of the federal manual, after the index. Any additional material should be clearly identified as state, tribal, or local requirements.

WHO NEEDS TO READ THIS SECTION?

You probably need to comply with the WPS if you are a:

- **Manager or owner** of a farm, forest, nursery, or greenhouse, ***or***
- **Labor contractor** for a farm, forest, nursery, or greenhouse, ***or***
- **Custom (for-hire) pesticide applicator** or **independent crop consultant** hired

by a farm, forest, nursery, or greenhouse operator. Most WPS provisions are protections that you as an **employer** must provide to **your own employees** and, in some instances, to **yourself**. The WPS covers two types of employers, which it defines according to the type of work their employees do:

Worker employer — If you hire or contract for people to do agricultural worker tasks, or if you do them yourself, the WPS considers you a worker employer. In general, agricultural workers are persons who
(1) do hand labor tasks, such as weeding, planting, cultivating, and harvesting, or
(2) do other tasks involved in the production of agricultural plants, such as moving or operating irrigation equipment. This manual will also describe the WPS protections you must provide to the agricultural workers you employ.

Handler employer — If you hire people to do pesticide handling tasks, or if you do them yourself, the WPS considers you a handler employer. In general, pesticide handlers are persons who mix, load, apply, or do other tasks that bring them into direct contact with pesticides. You must provide WPS protections to all your pesticide handler employees, whether or not they are certified as applicators of restricted-use pesticides. This manual will also describe the WPS protections you must provide to the pesticide handlers you employ.

- *The same employee may be a worker at some times and a handler at other times, depending on the type of task being performed.*
- *You may be both a handler employer and a worker employer, depending on the tasks that you and your employees do.*
- *Both general-use pesticides and restricted-use pesticides are covered by the WPS.*

1. Only appropriately trained and equipped workers are allowed in the area during pesticide application.
2. Workers may enter a treated area before the REI has expired only if the worker will have no contact with pesticide residue or is entering for a short term, emergency, or specifically accepted tasks.
3. Workers must be provided with protective equipment in proper working order. Workers must be notified of pesticide applications, treated areas must be posted, and/or oral warnings must be given to workers as directed by labeling.
4. A Pesticide safety poster must be on display in a central location.
5. A Decontamination site must be provided and maintained if workers are required to enter treated area during REI and the ensuing 30 days.
6. Emergency assistance must be provided to any worker when there is reason to believe the worker was poisoned or injured by pesticide.

Workers in several occupations may be exposed to pesticides by:
Preparing pesticides for use, such as by mixing a concentrate with water or loading the pesticide into application equipment.

Applying pesticides, such as in an agricultural or commercial setting.

Entering an area where pesticides have been applied to perform allowed tasks, such as picking crops.

The WPS *does not apply* when pesticides are applied on an agricultural establishment in the following circumstances:
For mosquito abatement, Mediterranean fruit fly eradication, or similar wide-area public pest control programs sponsored by governmental entities. The WPS does apply to cooperative programs in which the growers themselves make or arrange for pesticide applications.

On livestock or other animals, or in or about animal premises.

On plants grown for other than commercial or research purposes, which may include plants in habitations, home fruit and vegetable gardens, and home greenhouses.

On plants that are in ornamental gardens, parks, and public or private lawns and grounds that are intended only for aesthetic purposes or climatic modification.

By injection directly into agricultural plants. Direct injection does not include "hack and squirt," "frill and spray," chemigation, soil-incorporation, or soil-injection.

In a manner not directly related to the production of agricultural plants, such as structural pest control, control of vegetation along rights-of-way and in other non-crop areas, and pasture and rangeland use.

For control of vertebrate pests.

As attractants or repellents in traps.

On the harvested portions of agricultural plants or on harvested timber.

For research uses of unregistered pesticides.

This "How to Comply" section of the course will:

- Help you determine whether you are covered by the WPS,
- Give you detailed information on how to comply with the WPS requirements, including exceptions, restrictions, exemptions, options, and examples, and
- Provide you with a "Quick Reference Guide" — a simplified route to compliance that focuses on **maximum** requirements. Important definitions and other special explanations are enclosed in shaded boxes. Reading them will help you better understand the WPS requirements and how they apply to you.

LABELING OVERRIDES WPS

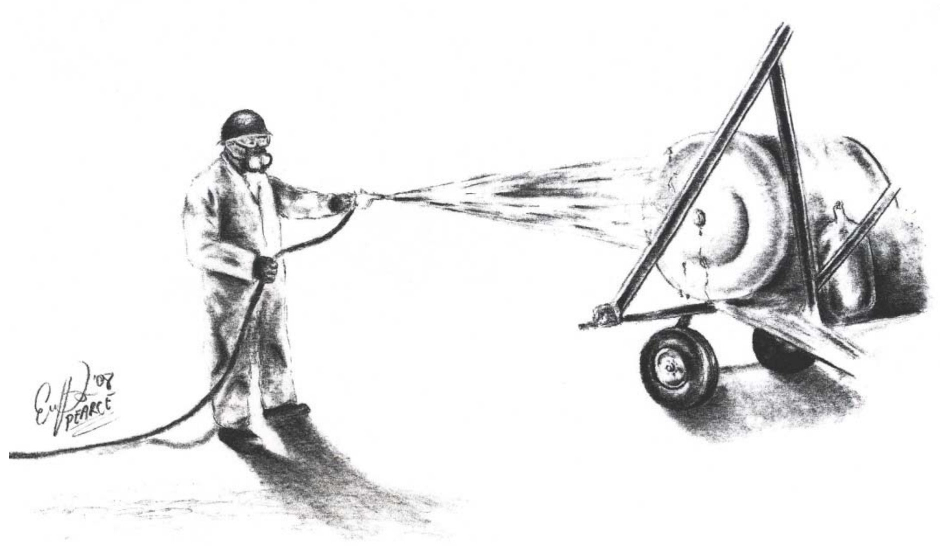
If the pesticide product labeling contains specific instructions or requirements that conflict with the requirements of the Worker Protection Standard, **follow the instructions or requirements on the labeling**. For example, some pesticide labeling may:

- Prohibit any early-entry activity, including short-term and emergency tasks.
- Allow an early-entry activity that the WPS does not allow.
- Require the use of personal protective equipment even if closed systems are used for mixing and loading.

EXCEPTIONS TO LABELING STATEMENTS

The WPS allows certain exceptions to three specific pesticide labeling requirements: **personal protective equipment**, **restricted-entry intervals**, and **double notification** (the requirement on some labeling for both oral warnings **and** posting treated areas). The WPS statements in the Agricultural Use Requirements box on the product labeling will tell you that the WPS contains these exceptions.

Entry during a restricted-entry interval is permitted only in a few strictly limited circumstances; see Early Entry.



Knowledge of Labeling Information

A handler employer must assure that handlers understand all of the labeling requirements related to safe use of pesticides before any handling activity takes place. The handler must also have access to the product labeling information during handling activities.

Safe Operation of Equipment
A handler employer must assure that handlers are instructed in the safe operation of all equipment they will be using. It is the handler-employer's responsibility to assure that the equipment is working properly and to inform employees, when appropriate, that the equipment may be contaminated with pesticides and to explain the correct way to handle such equipment.

Personal Protective Equipment
Any person handling a pesticide must use the clothing and PPE specified on the label for product use. Characteristics of protective clothing and PPE are specified in the standard, as are exceptions to PPE specified on product labeling. The handler employer must take appropriate measures to prevent heat-related illnesses.

Decontamination
A handler employer must provide a decontamination site (as specified in the standard) for washing off pesticides and pesticide residues during any handling activity.

Emergency Assistance
A handler employer must provide the same emergency assistance to handlers as discussed for workers.

Implementation
The requirements of WPS was phased into effect back in 1992 and again in 2005. First, labeling requirements went into effect on April 21, 1993. Before that date, the EPA did not allow the statements required by the WPS to be on labels. The period back in October 22, 1992-April 21, 1993 allowed the EPA to inform registrants how to correctly revise their labels and to inform end-users about the label-specific requirements by which they must abide. The following label-specific requirements must appear on pesticide labels:

- ✓ PPE (must be worn, but the employer is not required to provide, clean, or maintain until after April 15, 1994) (EPA, 1993a),
- ✓ the REI, and,
- ✓ on some pesticide labels, a requirement to provide both oral warnings (location and description of treated area, REI, and not to enter during REI) and a treated area posting (at entrance to treated area) (EPA, 1992b and EPA, 1993a).

Label Requirements

When these requirements appear on pesticide labels, all end-users must meet them unless exempt. Exempt end-users should voluntarily obey the requirements because of the dangers of pesticide exposure.

Second, beginning April 15, 1994, the generic requirements will be enforced. Generic requirements are intended to eliminate exposure to pesticides and to inform employees about the occupational hazards of pesticides. These require employers to make sure that employees are provided with:

- ✓ A display of information at a central location (WPS safety poster, the location of emergency medical facilities, and a list of recent pesticide applications).
- ✓ A decontamination facility.
- ✓ Pesticide safety training.
- ✓ Details of information exchanges between employers of agricultural workers and employers of commercial (for-hire) pesticide applicators.
- ✓ Notice about pesticide applications and information about pesticides used.
- ✓ Monitoring of handlers who are using highly toxic pesticides.
- ✓ Instruction on equipment safety, including inspection and maintenance.
- ✓ Instruction on the cleaning, inspection, and maintenance of PPE.
- ✓ Special instructions for handlers, including labeling information and safe operation of application equipment.
- ✓ Special application restrictions in nurseries and greenhouses.
- ✓ Emergency assistance when required (EPA, 1992a and EPA, 1993b).

Enforcement

States have primary enforcement responsibility for pesticide use violations if the Administrator of the EPA determines the State:
(1) has adopted adequate pesticide use laws and regulations;
(2) has adopted or is implementing adequate procedures for the enforcement of its laws and regulations; and
(3) has kept records and made reports showing compliance with (1) and (2) above, as the Administrator may require by regulation.

The Administrator of the EPA may also enter into cooperative agreements with States and Indian tribes to delegate the authority to cooperate in the enforcement of FIFRA.

Violations of the WPS carry both civil and criminal penalties.

Exceptions

Exceptions to the WPS are for pesticide application on an agricultural establishment in the following circumstances (**40 CFR**):

For mosquito abatement, Mediterranean fruit fly eradication, or similar wide-area public pest control programs sponsored by governmental entities.

On livestock or other animals, or in or about animal premises.

On plants grown for other than commercial or research purposes, which may include plants in habitations, home fruit and vegetable gardens, and home greenhouses.

On plants that are in ornamental gardens, parks, and public and private lawns and grounds that are only intended for aesthetic purposes or climatic modification.

By injection directly into agricultural plants. Direct injection does not include ***"hack and squirt,"*** "***frill and spray***," chemigation, soil-incorporation, or soil injection.

In a manner not directly related to the production of agricultural plants, including, but not limited to, structural pest control, control of vegetation along rights-of-way and in non-crop areas, and pastures and rangeland use.

For control of vertebrate pests.

As attractants or repellents in traps.

On the harvested portions of agricultural plants or on harvested timber.

For research uses of unregistered pesticides.

Exemptions

Exemptions from specific sections of the WPS apply only to owners of agricultural establishments and members of their immediate family while they are performing tasks related to the production of agricultural plants on their own agricultural establishments (40 CFR). These exemptions apply to the sections of the WPS covering the following:

Entry during a REI for short-term activities.

Entry during a REI for an agricultural emergency.

Entry during a REI for an EPA-granted exception.

Notice of application. Providing specific information about applications.

Pesticide safety training.

Posted pesticide safety information.

Decontamination and Emergency assistance.

The term "weed" means different things to different people. In the broadest sense, it is any plant growing where it is not wanted. Weeds can be native or non-native, invasive or non-invasive, and noxious or not noxious. Legally, a noxious weed is any plant designated by a federal, state or county government as injurious to public health, agriculture, recreation, wildlife or property. A noxious weed is also commonly defined as a plant that grows out of place (i.e. a rose can be a weed in a wheat field) and is "competitive, persistent, and pernicious."

The noxious weeds mandated for control are plants non-native to North America. Consequently, these plants do not have the natural checks as found in their native land, such as insects, diseases, and herbivores that would keep the plant population in check. Due to the competitive aggressive ability of these plants coupled with no natural controls, these plants will develop mono-culture stands. Not only are many crops out competed by these weeds but native vegetation and the wildlife associated with it will be replaced. Consequently, identifying the weeds when they first become established and developing an integrated weed management plan to control them is critical in maintaining healthy, productive land. The term noxious weed is used to describe a legal designation for plant species that have been determined to be especially undesirable or difficult to control.

WHICH PESTICIDE USES ARE COVERED?

Most pesticide uses involved in the production of agricultural plants on a farm, forest, nursery, or greenhouse are covered by the WPS. This includes pesticides used on plants, and pesticides used on the soil or planting medium the plants are (or will be) grown in. Both general-use and restricted-use pesticides are covered by the WPS. You will know that the product is covered by the WPS if you see the following statement in the Directions for Use section of the pesticide labeling:

"AGRICULTURAL USE REQUIREMENTS
Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment, notification of workers, and restricted-entry intervals."

If you are using a pesticide product with labeling that refers to the Worker Protection Standard, you must comply with the WPS. Otherwise, you will be in violation of federal law, since it is illegal to use a pesticide product in a manner inconsistent with its labeling.

WHICH PESTICIDE USES ARE NOT COVERED?

Some pesticide uses are not covered by the WPS, even when the "Agricultural Use Requirements" section is on the labeling. For example, if the pesticide labeling bears an "Agricultural Use Requirements" section, but the product also can be applied to rights-of-way, the rights-of-way use is not covered by the WPS. The WPS does ***not*** cover pesticides applied:

- on pastures or rangelands,
- for control of vertebrate pests such as rodents,
- as attractants or repellents in traps,
- on the portions of agricultural plants that have been harvested, such as in *WPS.*
- packing houses or on cut timber,
- for mosquito abatement, Mediterranean fruit fly eradication, or similar government-sponsored wide-area public pest control programs,
- on livestock or other animals, or in or around animal premises,
- on plants grown for other than commercial or research purposes, which may include plants in habitations, home fruit and vegetable gardens, and home greenhouses,
- on plants that are in ornamental gardens, parks, golf courses, and public or private lawns and grounds and that are intended only for decorative or environmental benefit,
- in a manner not directly related to the production of agricultural plants, including, for example, control of vegetation along rights of way and in other non-crop areas and structural pest control, such as termite control and wood preservation,
- for research uses of unregistered pesticides.

The WPS does not cover **workers** who are working in an area where a pesticide has been injected directly into the plants. However, people who **handle** pesticides that are to be *Direct injection does not* applied by direct injection ***are*** covered by the WPS and must receive handler protections.

Compensation *includes pay or wages, payment through services or goods, or barter of services or goods. If only one person receives payment for the joint work of several people, all are considered to be compensated, and are employees under the WPS. For example, under a piece-rate payment system for harvesting crops, even if payment is issued to the head of the family only, all of the family members who harvest crops are considered employees under the WPS.*

WHO MUST PROTECT WORKERS AND HANDLERS?

Employers are responsible for making sure that workers and handlers receive the protections required by the pesticide labeling and the WPS. The term “employer” has a special meaning in the WPS — you are an employer even though you are self-employed or use only members of your own family to do the work on your establishment.

The WPS has very specific definitions for two types of employers. WPS requirements apply only to employers who meet those definitions.

WPS EMPLOYER DEFINITIONS
Worker Employers:
Worker employers are people who:

- **employ or contract for the services of workers** (including themselves and members of their family) for any type of compensation to perform tasks related to the production of agricultural plants, or
- **own or operate** an agricultural establishment that uses such workers. (See definition of “owner,”.) (See definition of “worker,”.)

If you are a worker employer, you are responsible for providing your agricultural worker employees with the protections that the WPS requires for **workers**. (In the WPS itself, “worker employers” are called “agricultural employers.”)

Handler Employers:
Handler employers are people who:
- **employ pesticide handlers** (including members of their family), for any type of compensation, or
- **are self-employed as pesticide handlers**.

(See definition of “pesticide handler,”.)
If you are a handler employer, you are responsible for providing the pesticide handlers you employ with the protections that the WPS requires for **handlers**.

If You Employ Supervisors
You must:
- require them to make sure the workers and handlers they supervise comply with the WPS and receive its protections,
- give them enough information and directions about the WPS requirements to make sure that the workers and handlers they supervise receive the protections required by the WPS, and
- tell them who is responsible for all actions necessary for compliance with the WPS. Even if you assign an employee to carry out the duties required by the WPS, **you are responsible** for making sure that all those duties are performed.

Retaliation Prohibited
You and your supervisors must not prevent or discourage any worker or handler from complying or attempting to comply with the WPS, and you must not fire or otherwise retaliate against any worker or handler who attempts to comply.

Penalties for Noncompliance
Agricultural and handler employers can be subject to civil and criminal penalties if found not complying with the federal Worker Protection Standard including all revisions through 2004. Failure to comply is a pesticide misuse violation — also known as use of a pesticide in a manner inconsistent with its labeling. Failure to comply with distinct acts of the WPS may result in independently assessable charges, even if the violative acts occurred during one pesticide application.

Currently, a federal civil penalty of up to $1,100 per violation may be assessed against private applicators (owners/operators of agricultural establishments) and other persons, and up to $6,500 per violation against commercial applicators (owners/operators of pesticide handling establishments) and other persons. Since Congress passed the Civil Monetary Penalty Inflation Adjustment Rule under the Debt Collection Improvement Act of 1996, civil penalties have been increased due to inflation and Congress' intent on creating a deterrence to noncompliance. The next civil penalty adjustment is expected to occur in 2009.

Criminal penalties can also be assessed if the WPS is knowingly violated. Federal fines include up to $1,000 per offense and 30 days in jail for private applicators, and up to $25,000 and 1 year in jail for commercial applicators.

Labeling Overrides WPS
If the pesticide product labeling contains specific instructions or requirements that conflict with the requirements of the Worker Protection Standard, **follow the instructions or requirements on the labeling**.

For example, some pesticide labeling may:

- prohibit any early-entry activity, including short-term and emergency tasks,
- allow an early-entry activity that the WPS does not allow,
- require the use of personal protective equipment even if closed systems are used for mixing and loading.

Exceptions to Labeling Statements
The WPS allows certain exceptions to three specific pesticide labeling requirements: **personal protective equipment** , **restricted-entry intervals**, and **double notification** (the requirement on some labeling for both oral warnings **and** posting treated areas). The WPS statements in the Agricultural Use Requirements box on the product labeling will tell you that the WPS contains these exceptions.

Most states and tribes enforce under their own laws and regulations and have their own penalties, which may differ from federal penalties. Pesticide-related ordinances and associated penalties may also be imposed by local governments.

WHAT EMPLOYERS MUST DO FOR BOTH WORKERS AND HANDLERS

Some WPS protections that employers must provide are nearly the same whether the employees are workers or handlers. This unit describes those requirements. The following unit describes additional requirements that employers must provide to their employees who are **workers**. The next unit describes additional requirements that employers must provide to their employees who are **handlers**. If you employ both workers and handlers, you will need to read all three of these units.

INFORMATION AT A CENTRAL LOCATION

BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)

Worker employers must make sure that certain information, described below, is displayed at a central location whenever (1) any **worker** whom they employ is on their agricultural establishment, and
(2) a pesticide is about to be applied or has been recently applied.

When agricultural establishments employ their own handlers, **handler employers** of such establishments must make sure that certain information, described below, is displayed at a central location whenever (1) any **handler** whom they employ is on their agricultural establishment, and (2) a pesticide has been recently applied. However, this information does not need to be displayed if only commercial (custom) pesticide handlers will be on the agricultural establishment.

SPECIFIC DUTIES

What Information Must Be Displayed?

The following three types of information must be displayed at a central location before a pesticide is applied:
1. Pesticide-specific application information, which must include: the location and description of the area to be treated, product name, EPA registration number, and active ingredient(s) of the pesticide, time and date the pesticide is scheduled to be applied, and restricted-entry interval for the pesticide.
2. Emergency information, which must include the name, telephone number and address of the nearest emergency medical facility.
3. A pesticide safety poster, which must be either the WPS safety poster developed by EPA or an equivalent poster that contains the concepts listed in Criteria for Pesticide Safety Poster.

Where Must the Information Be Displayed?

Display the required information together in a central location on your agricultural establishment where it is readily accessible and can be easily seen and read by workers and handlers.

Exception

If the workplace is a forest, you may display the information **near** the forest. It must be in a location where workers and handlers can easily see and read it and where they are likely to gather or pass by. For example, you might display the information with the decontamination supplies or at an equipment storage site.

When Must the Information Be Displayed?
Display the information whenever **any worker or handler** you employ is on your agricultural establishment and, in the past 30 days, a pesticide has been applied or a restricted-entry interval has been in effect. The information may be displayed continuously.

Commercial pesticide handler employers *do* **not** *need to display this information on the commercial pesticide handling establishment. If the pesticide is not applied as scheduled, you must display the corrected time and date before the application takes place. If you are unable to make the correction before the application takes place, make it as soon as possible thereafter.*

Earlier display: If you post WPS warning signs at treated areas, you must display pesticide-specific information at the central location no later than the time when the warning signs are posted.

Timing of Displaying Application Information
1. If workers or handlers are on your establishment at the start of an application, display the required pesticide-specific information **before the application takes place**.
2. If workers or handlers are ***not*** on your establishment at the start of an application, display pesticide-specific information **no later than the beginning of their first work period**.
3. Continue to display pesticide-specific information when workers or handlers are on your establishment **until:**

- at least 30 days after the restricted-entry interval expires, or
- at least 30 days after the end of the application, if there is no restricted-entry interval for the pesticide.

Other Responsibilities
1. Inform workers and handlers where the information is located.
2. Allow workers and handlers free, unhampered access to the information.
3. Be sure that the poster, emergency information, and application information remain legible during the time they are posted.
4. Promptly inform workers if there is any change in the information on emergency medical facilities and update the emergency information listed with the poster.

How To Comply With the Worker Protection Standard For Agricultural Pesticides

Restrictions During Applications
1. In areas being treated with pesticides, allow entry only to appropriately trained and equipped handlers.
2. Keep nursery workers at least 100 feet away from nursery areas being treated.
3. Allow only handlers to be in a greenhouse during a pesticide application, until labeling-listed air concentration level is met or, if no such level, until after 2 hours of ventilation with fans. (Also see nursery restrictions and greenhouse restrictions)

Restricted-Entry Intervals (REIs) During any REI, do not allow **workers** to enter a treated area and contact anything treated with the pesticide to which the REI applies. (Also see early entry by workers)

Notice About Applications
1. Orally warn workers **and** post treated areas if the pesticide labeling requires.

2. Otherwise, **either** orally warn workers or post entrances to treated areas. Tell workers which method is in effect.

3. Post all greenhouse applications.

Posted Warning Signs
1. Post legible 14" x 16" WPS-design signs just before application; keep posted during REI; remove before workers enter and within 3 days after the end of the REI.

2. Post signs so they can be seen at all entrances to treated areas, including entrances from labor camps.

Oral Warnings
1. Before each application, tell workers who are on the establishment (in a manner they can understand): location and description of treated area, REI, and not to enter during REI.

2. Workers who enter the establishment after application starts must receive the same warning at the start of their work period.

WHAT EMPLOYERS MUST DO FOR BOTH WORKERS AND HANDLERS PESTICIDE SAFETY TRAINING

BASIC RESPONSIBILITIES
(See Also Specific Duties Section Below)

Handler employers must make sure that **handlers** are trained, as described below, about general pesticide safety and about correct ways to handle pesticides.

Worker employers must make sure that **workers** have been trained, as described below, about general pesticide safety. This includes workers who enter treated areas on the farm, forest, nursery, or greenhouse during a restricted-entry interval to perform WPS-permitted tasks.

SPECIFIC DUTIES Providing Basic Pesticide Safety Information to Untrained Workers

You must provide basic pesticide safety information to **untrained** workers before they enter treated areas on your establishment where, within the past 30 days, a pesticide has been applied or a restricted-entry interval has been in effect.

You must:

- provide the basic pesticide safety information in a manner that the untrained workers can understand, such as through written materials, oral communication, or other means,
- be able to verify that you provided the workers with the required basic pesticide safety information,
- provide the workers with at least the following information: – Pesticides may be on or in plants, soil, irrigation water, or drifting from nearby applications.

To prevent pesticides from entering your body:

- Follow directions and/or signs about keeping out of treated or restricted areas,
- Wash before eating, drinking, using chewing gum or tobacco, or using the toilet,
- Wear work clothing that protects your body from pesticide residues,
- Wash/shower with soap and water, shampoo hair, and put on clean clothes after work,
- Wash work clothes separately from other clothes before wearing them again,
- Wash immediately in the nearest clean water if pesticides are spilled or sprayed on your body and then —as soon as possible — shower, shampoo, and change into clean clothes.
- You will receive more training within 5 days (or at least before your sixth day of work in pesticide-treated areas on this establishment).

Who Must Be Trained?

Each worker and handler must be trained. This requirement is met if the worker or handler:

1. has been trained within the last 5 years as a WPS handler or WPS worker, even if he or she has changed employers, *or*
2. is currently a certified applicator of restricted-use pesticides, *or*
3. is currently trained (as specified in EPA's certification and training regulations) as a handler who works under the supervision of a certified pesticide applicator.

Entry during a restricted-entry interval is permitted only in a few strictly limited circumstances.

Under the WPS, you may be both a handler and an employer of handlers.

How Soon Must They Be Trained?
1. **Handlers** must be trained before they do any handling task.
2. **Early-entry workers who will contact anything** that has been treated with the pesticide which caused the restricted-entry interval must be trained ***before*** they do any early-entry task on your establishment.
3. **Other agricultural workers, including early-entry workers who will *not* contact anything** that has been treated with the pesticide which caused the restricted-entry interval must be trained ***before*** they accumulate more than 5 separate days of entry into treated areas on your establishment where, within the past 30 days, a pesticide has been applied or a restricted-entry interval has been in effect. These 5 days of entry need not be consecutive and are not limited to a growing season or calendar year.

Note: You must provide **untrained** workers with basic pesticide safety information before they enter into treated areas on your establishment where, within the past 30 days, a pesticide has been applied or a restricted-entry interval has been in effect.

How Often Must Handlers and Workers Be Trained?
Handlers and workers must be trained at least once every 5 years, counting from the end of the month in which the previous training was completed.

Who Can Conduct Training?
1. The person who conducts **handler** training must:
• currently be a certified applicator of restricted-use pesticides (in any category of certification),
or
• currently be designated as a trainer of certified pesticide applicators or pesticide handlers by a state, federal, or tribal agency having jurisdiction,
or
• have completed a pesticide safety train-the-trainer program approved by a state, federal, or tribal agency having jurisdiction.
2. The person who conducts **worker** training must:
• currently be qualified to present handler training, as described immediately above,
or
• currently be trained as a WPS handler,
or
• have completed a pesticide safety train-the-trainer program approved by a state, federal, or tribal agency having jurisdiction.

How To Conduct Training
1. Anyone who conducts **worker** or **handler** training must:
  • use written and/or audiovisual materials,
  • present the training orally or audiovisually,
  • present the information in a manner that the trainees can understand, using a translator, if necessary,
  • respond to trainees' questions.
2. Anyone who conducts **worker** training must use non-technical terms.

Content of Training
The pesticide safety training materials for **workers and handlers** must be either:

- WPS training materials developed by EPA,

or

- equivalent material that contains at least the concepts listed in Criteria for Worker and Handler Training.

Verification of Training
If you make sure that a **handler** has an EPA-approved WPS handler training card or that a **worker** has an EPA-approved WPS worker or handler training card, the person does not have to be retrained ***unless*** you are aware, or have reason to know, that the card is invalid.

A WPS training card is invalid if you, the employer:

- are aware, or have reason to know, that the card was not issued according to the criteria in the WPS. For example, you know that the person who gave the training was ***not*** qualified to conduct WPS training, or that the content of the training did ***not*** meet the WPS criteria, or the trainee could ***not*** understand the training when it was given.

or

- are aware, or have reason to know, that the card was not issued to the person who has the card.

or

- know that the training for which the card was issued took place more than 5 years before the beginning of the current month (the card has expired).

Avoiding Discrimination in Hiring
Even if you do not normally provide training in the particular language of a job applicant, or if a translator is not readily available, you are not exempted from your training responsibilities under the WPS.

Refusing to hire an applicant who cannot understand the language or languages in which you usually provide training may constitute discrimination on the basis of national origin. Such discrimination is actionable under Title VII of the Civil Rights Act of 1964 or the Immigration Reform and Control Act of 1986 (IRCA). If you want information about your responsibilities under Title VII of the Civil Rights Act of 1964, contact the U.S. Equal Employment Opportunity Commission. For details about IRCA anti-discrimination provisions, contact the Special Counsel for Immigration-Related Unfair Employment Practices, U.S. Department of Justice.

Handlers who are currently certified as applicators of restricted-use pesticides must be given all of the WPS handler protections, except that they need not receive WPS training.

The WPS requires that decontamination supplies be provided regardless of the number of employees. There is **no** *exemption for employers with only a few employees.*

Note: *For* ***early-entry workers who will contact*** *anything that has been treated with the pesticide, the decontamination supply requirements are different.*

***Decontamination and emergency eyeflush water** must, at all times when it is available to workers or handlers, be of a quality and temperature that will not cause illness or injury when it contacts the skin or eyes or if it is swallowed.*

DECONTAMINATION SUPPLIES BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)
Handler employers must make sure that decontamination supplies (described below) for washing off pesticides and pesticide residues are provided to **handlers** while they are doing handling tasks. **Worker employers** must make sure that decontamination supplies (described below) for washing off pesticide residues are provided to **workers** who are working in a pesticide-treated area and are doing tasks that involve contact with anything that has been treated with the pesticide, including soil, water, or surfaces of plants.

SPECIFIC DUTIES
When Must the Supplies Be Provided?
For **handlers**, for the duration of the handling task.
For **workers**, until 30 days after the end of any restricted-entry interval for that area. If there is no restricted-entry interval, until 30 days after the end of any application in that area.

Exception
When the only pesticides used in the treated area are products with a restricted-entry interval of 4 hours or less, the decontamination supplies must be provided until 7 days after the end of the restricted-entry interval. ***Note:*** When products have no restricted-entry interval listed on the label, the decontamination supplies must be provided until 30 days after the end of any application in that area.

For **early-entry workers who will contact** anything that has been treated with the pesticide, the decontamination supply requirements are different.

Supplies
Provide workers and handlers with:
1. **Water** — enough for:
    - routine washing, and
    - emergency eyeflushing.

*If the water is stored in a tank, the water **must not** be used for mixing pesticides, unless the tank is equipped with correctly functioning anti-backsiphoning or check valves or other mechanisms (such as air gaps) that prevent pesticides from moving into the tank.*
2. **Soap and single use towels** — enough for workers' or handlers' needs.
3. **For handlers**, ***also*** provide:
    - **enough water for washing the entire body** in case of emergency, and
    - **clean change of clothes**, such as one-size-fits-all coveralls, to put on if the handlers' garments are contaminated and need to be removed right away.

Recommendation: How Much Water Should Be Provided?
Obviously, running water meets the requirement. However, if it is not available, use the following guidelines.
• **Workers:** At least 1 gallon of water is recommended for each worker using the supplies. If you find that 1 gallon per worker is inadequate to last for the entire work period, provide more water or replenish the water as needed during the work period.

•**Handlers:** At least 3 gallons of water is recommended for each handler using the supplies. If you find that 3 gallons per handler is inadequate to last for the entire work period, provide more water or replenish the water as needed during the work period.

Location
1. All decontamination supplies for workers must be located together and all decontamination supplies for handlers must be located together. Decontamination supplies must be reasonably accessible to the workers and handlers. Handlers mixing pesticides must have decontamination supplies at the mixing area.

Exceptions:

- For a pilot who is applying pesticides aerially, the decontamination supplies must be at the aircraft's loading site or in the aircraft.
- For tasks performed more than 1/4 mile from the nearest point reachable by vehicles (cars, trucks, or tractors), the decontamination supplies may be at the access point. In this circumstance, clean water from springs, streams, lakes, or other sources may be used for decontamination if such water is more readily available than the water at the access point.

Worker decontamination supplies must ***not*** be in an area being treated with pesticides or in an area under a restricted-entry interval.

Handler decontamination supplies may be located in an area being treated with pesticides (or an area that has a restricted-entry interval in effect), **only if**:

- They are in the area where the handler is doing handling tasks, *and*
- The soap, single-use towels, and clean change of clothing are in closed containers,*and*
- The water is running tap water or is in a closed container.

Emergency Eyeflushing
Provide each **handler** with at least 1 pint of emergency eyeflush water when the pesticide labeling requires protective eyewear for the handling task being performed. The emergency eyeflush water must be **immediately accessible**. For example, it could be carried by the handler or be on a vehicle the handler is using. The water that is supplied for general decontamination may also be used as eyeflush water, if it is immediately accessible.

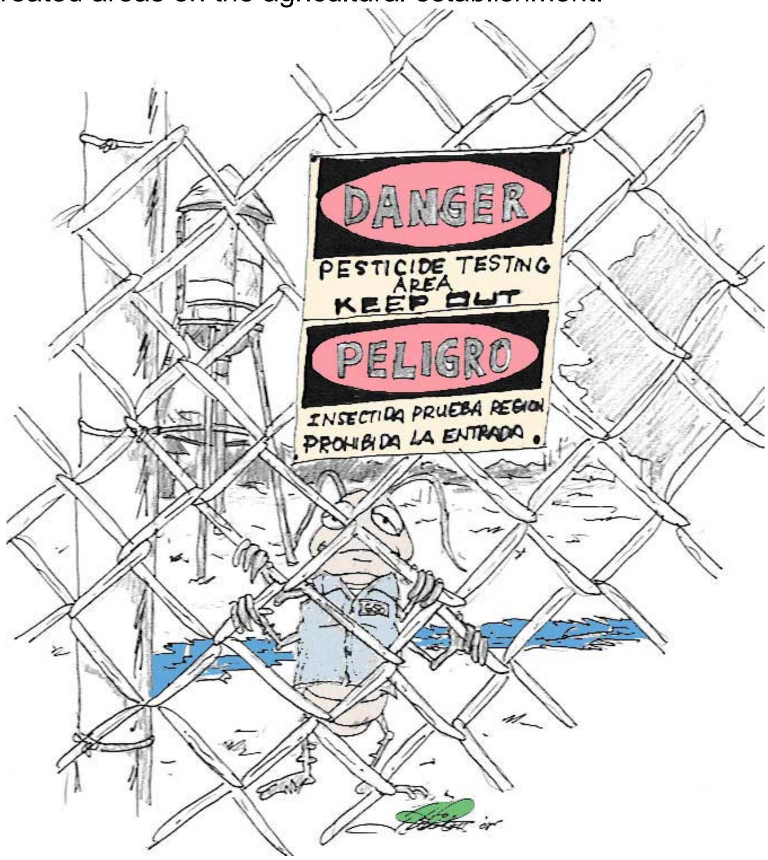
Decontamination After Handling Tasks
At the site where handlers remove their personal protective equipment (PPE), provide:

- soap,
- clean towels, and
- enough water to allow handlers to wash thoroughly after removing PPE.

If the pesticide is not applied as scheduled, you must display the corrected time and date before the application takes place. ***If you are unable to make the correction before the application takes place, make it as soon as possible thereafter.***

Employers of commercial pesticide handlers
must make sure that their customer — the operator of the farm, forest, nursery, or greenhouse — knows certain information, described below, about the pesticide before it is applied on the establishment. **Operators of farms, forests, nurseries, and greenhouses** (agricultural employers) must make sure that, whenever a **commercial handler** will be doing pesticide handling tasks (including tasks as a crop advisor) on their establishment, the **commercial handler's employer knows specific information**, described below, concerning treated areas on the agricultural establishment.

SPECIFIC DUTIES
Information for Establishment Operators
Commercial handler employers must inform their customer — the operator of the farm, forest, nursery, or greenhouse — about:



• the specific location and description of the area(s) on the agricultural establishment that are to be treated with a pesticide,
• time and date the pesticide is scheduled to be applied,
• product name, EPA registration number, and active ingredient(s),
• restricted-entry interval for the pesticide,
• whether the pesticide labeling requires both treated-area posting **and** oral notification, and
• any other specific requirements on the pesticide labeling concerning protection of workers and other persons during or after application. Operators of agricultural establishments must have this information to protect their employees.

Information for Commercial Handler Employers
Operators of agricultural establishments must provide the following information to the commercial pesticide handler employer that they hire:

• Specific location and description of any areas on the agricultural establishment:
– that may be treated with a pesticide or be under a restricted-entry interval while the commercial handler will be there, *and* – that the commercial handlers may be in (or walk within 1/4 mile of).
• Restrictions on entering those areas. Operators of commercial pesticide handling establishments must have this information to protect their employees.

EMERGENCY ASSISTANCE BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)
Worker employers must provide emergency assistance, described below, to anyone who is or has been employed as a **worker** on their farm, forest, nursery, or greenhouse if there is reason to believe that the worker has been poisoned or injured by a pesticide used on the agricultural establishment — for example, through application, spills, splashes, drift, or contact with pesticide residues. **Pesticide handler employers** must provide emergency assistance, described below, to anyone who is or has been employed as a **handler** on their farm, forest, nursery, or greenhouse or on their commercial pesticide handling establishment, if there is reason to believe that the handler has been poisoned or injured by a pesticide as a result of that employment — for example, through application, spills, splashes, drift, handling tasks, or contact with pesticide residues.

SPECIFIC DUTIES Emergency Transportation
1. Promptly make emergency transportation available to take the **worker** to an emergency medical facility able to provide treatment:

- from the agricultural establishment, *or Employers can "make transportation taking the employee to the emergency medical facility,* or *calling an such as an ambulance,* or *making sure the employee has a ride to the medical and facility with someone else.*
- from a labor camp located on the establishment.

2. Promptly make emergency transportation available to take the **handler** to an *available" by:* emergency medical facility able to provide treatment:

- from the agricultural establishment, *or*
- from another handling site, such as a commercial handling establishment or an airport hangar.

Emergency Information
Provide to the worker or handler or to treating medical personnel, promptly upon *emergency vehicle,* request, any obtainable information on:

- product name, EPA registration number, and active ingredients for any product(s) to which the person may have been exposed,
- antidote, first aid, statement of practical treatment and other medical or emergency information from the product labeling,
- description of the way the pesticide was being used,
- circumstances of the worker's or handler's exposure to the pesticide.

Emergency Assistance

If there is reason to believe that a worker has been poisoned or injured by pesticides, the employer must make prompt transportation to a medical facility available to the worker. On request the employer must provide, to either the worker or medical personnel providing treatment, information about the product including the EPA registration number, active ingredients in any product the worker might have been exposed to in the past 30 days, antidote and other first aid information from the product labeling, and information about the application and the exposure of workers to the pesticide.

Requirements for Handlers
The general applicability, exceptions and exemptions in the requirements for handlers and workers are the same. However, the requirements for handlers have specific differences.

Restrictions During Application
The handler employer must assure that:

- No pesticide is applied so as to contact any worker (directly or through drift) other than an appropriately trained and equipped handler.
- Workers handling highly toxic pesticides are monitored visually or by voice communication at least every 2 hours.
- Any worker who handles a fumigant in a greenhouse, including a handler entering before acceptable safe entry criteria have been met, maintains continuous visual or voice contact with another handler who has immediate access to the required PPE if rescuing the handler in the greenhouse becomes necessary.

Notice of Application to Agricultural Employers
Prior to applying any pesticide on an agricultural establishment, a handler employer must provide the following information to an agricultural employer or be assured that the agricultural employer is aware of the specific time, date, location, and description of the pesticide-treated area, labeling requirements relating to protection of workers during or after application, product name, the EPA registration number, active ingredients, REI, and notification requirements.

Pesticide Safety Training
A handler employer must assure that each handler is properly trained in pesticide safety by a qualified trainer. The minimum pesticide training required, as well as the criteria for qualified trainers, is specified in the standard. Certified handlers and handlers who have been trained under 40 Code of Federal Regulations, Part 171 are exempt from this requirement.

FURTHER REQUIREMENTS FOR EMPLOYERS OF WORKERS NOTICE ABOUT APPLICATIONS BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)
Under most circumstances, **worker employers** must make sure that **workers** are notified about areas where pesticide applications are taking place or where restricted-entry intervals are in effect.

SPECIFIC DUTIES Both Oral Warnings and Posted Signs
Some pesticide labels require you to notify workers ***both*** orally ***and*** with signs posted at entrances to the treated area. If both types of notification are required, the following statement will be in the "Directions for Use" section of the pesticide labeling under the heading "Agricultural Use Requirements":

"**Notify workers of the application by warning them orally and by posting warning signs at entrances to treated areas**."

Notification on Farms, Forests, and Nurseries
Unless the pesticide labeling requires both types of notification, notify workers ***either*** orally ***or*** by the posting of warning signs at entrances to treated areas. You must inform workers which method of notification is being used.

Notification in Greenhouses
In greenhouses, **you must post all treated areas**, except as described below. If the pesticide labeling requires both types of notification, you must also notify workers orally.

Exceptions to Worker Notification
1. **Oral warnings** need ***not*** be given to:

- **any** worker on your farm, forest, or nursery who will not be in the treated area, or walk within 1/4 mile of a treated area, during the pesticide application or while the restricted-entry interval is in effect,
- **any** worker who will not be in your greenhouse during a pesticide application or while a restricted-entry interval is in effect there, ***or***
- **any** worker who applied (or supervised the application of) the pesticide and is aware of all of the information required to be given in the oral warning.

2. Treated area posting is ***not*** required if:

- **no** workers on your farm, forest, or nursery will be in the treated area, or walk within 1/4 mile of the treated area, during the pesticide application or while the restricted-entry interval is in effect,
- **no** workers will be in the greenhouse during the pesticide application or while the restricted-entry interval is in effect there, ***or***
- the **only** workers for whom you need to post applied (or supervised the application of) the pesticide and are aware of all of the information required to be given in the oral warning.

Posted Warning Signs *Signs meeting these* Use WPS-design signs when you post warnings at entrances to treated areas. For a *requirements should be* detailed description, see Requirements for Warning Signs.

1. **Location:**
• **On farms, forests, and nurseries**, post the signs so they can be seen from all points where workers usually enter the treated area, including at least: – each access road, – each border with any labor camp adjacent to the treated area, and – each established walking route that enters the treated area.

When there are no usual points of worker entry, post the signs in the corners of the treated area or in places where they will be most easily seen.
• **In greenhouses**, post the signs so they can be seen from all points where workers usually enter the treated area, including doorways, aisles, and other walking routes. When there are no usual points of worker entry to the treated area, post the signs in the corners of the treated area or in places where they will be easily seen.

2. **Timing and Visibility of Warning Signs**:
• Post signs 24 hours or less before the scheduled application of the pesticide.
• Keep signs posted during application and throughout the restricted-entry interval (if any),
• Remove the signs within 3 days after the end of the restricted-entry interval. If there is no restricted-entry interval for that application, remove the signs within 3 days after the end of the application.
  • Keep workers out during the entire time the signs are posted, (except for trained and equipped early-entry workers entering as permitted under WPS).
  • Keep signs visible and legible while they are posted.

3. **Posting Adjoining Areas** When several adjoining areas are to be treated with pesticides on a rotating or sequential *Requirements for Warning Signs,* you may post the entire area at the same time. Worker entry, except for early entry *description, see* permitted by the WPS, is prohibited for the entire area while the signs are posted.

4. **Design and Size**
  • Each warning sign must look like this:

Exception:
As an option, you may use warning signs that replace the Spanish words with the same words in **Red** another language (other than English) that is read by the largest number of your workers who do not read English. The replacement sign must meet all other requirements for the WPS warning sign.
  • You may put **additional information** on the warning sign, such as the name of the pesticide or the date of application, if it does not lessen the impact of the sign or change the meaning of the required information. If you add the required information in other languages, the words must be translated correctly.
  • The signs must be at least 14 inches by 16 inches, and the letters must be at least 1 inch high.

Exception:
On farms and forests, you may use smaller signs if the treated area is too small to accommodate 14- by 16-inch signs. For example, when a single plant needs to be posted, a smaller sign would be appropriate. In nurseries and greenhouses, you may, at

any time, use a sign smaller than the standard size. Whenever a small sign is used, there are specific posting distances depending on the size of the lettering and symbol on the sign (see table below).

Sign Size
Signs with the words "DANGER" and "PELIGRO" in letters less than *7/16 inch in height **or** with any words in letters* less than *1/4 inch in height **or** with the circle graphic containing an upraised hand and a stern face* less than *1½ inches in diameter do not meet WPS sign requirements.*

* This distance requirement is for places where multiple signs are used to post a single treated area, such as a field or a greenhouse section. It does not apply where individual signs are used for separate small treatment areas (such as single potted plants in a greenhouse).

Oral Warnings to Workers
1. **Content**:
Oral warnings must include:
- the location and description of the treated area,
- the time during which entry is restricted, and
- instructions not to enter the treated area until the restricted-entry interval has expired.

2. **Communication**:
Provide oral warnings to workers in a manner that they can understand.

3. **Timing**:
- Workers who are on your establishment at the start of an application must be orally warned **before the application takes place**.
- Workers who are ***not*** on your establishment at the start of an application must be orally warned **at the beginning of their first work period** if (1) the application is still taking place or (2) the restricted-entry interval for the pesticide is in effect.

*Entering either enclosed or outdoor fumigated areas to ventilate, remove tarps or other coverings used in the fumigation, or to measure air concentration levels are **handling tasks**, not early entry. Only appropriately trained and equipped handlers can do these tasks.*

RESTRICTIONS DURING AND AFTER APPLICATIONS
BASIC RESPONSIBILITIES
Worker employers must take actions, described below, to protect **workers and other persons** during pesticide applications on agricultural establishments. **Worker employers** also must take actions, described below, to protect **workers** during restricted-entry intervals.

SPECIFIC DUTIES During Applications
1. Keep everyone except appropriately trained and equipped handlers out of areas being treated with pesticides.
2. In nurseries and greenhouses, during some applications, also keep workers and other persons out of the area **immediately around** the area being treated. The size of this "keep-out zone" depends on the pesticide used and the application method. In some

greenhouse situations, the greenhouse must be adequately ventilated before workers are allowed to enter.

During Restricted-Entry Intervals
In general, keep workers out of a treated area during the restricted-entry interval. This restriction has only two types of exceptions: (1) early entry **with no contact**, described below, and (2) early entry **with contact** for short-term, emergency, or specially excepted tasks. Note, however, that entry into treated areas during a restricted-entry interval is also allowed to perform handling (including crop advisor) tasks as long as the persons entering such areas are trained and equipped as pesticide handlers and receive all other applicable WPS handler protections.

RESTRICTED-ENTRY INTERVAL (REI)
The restricted-entry interval is the time immediately after a pesticide application when entry into the treated area is limited. Some pesticides have one REI, such as 12 hours, for all crops and uses. Other products have different REIs depending on the crop or method of application. When two (or more) pesticides are applied at the same time, and have different REIs, you must follow the longer interval.

Location of REIs on Labeling
The restricted-entry interval is listed on the pesticide labeling:
•under the heading “Agricultural Use Requirements” in the “Directions for Use” section of the pesticide labeling, or
•next to the crop or application method to which it applies.

Arid Area REIs
Some pesticide labeling require a different REI for arid areas. Labeling might say, for example, “72 hours in outdoor areas where average annual rainfall is less than 25 inches a year.” You can get information on average annual rainfall for your area from any nearby weather bureau, such as one located at a local airport or one affiliated with the National Oceanographic and Atmospheric Administration.

NO-CONTACT EARLY ENTRY
If workers **will have no contact with anything that has been treated with the pesticide** to which the restricted-entry interval applies, you may permit them to enter pesticide-treated areas when the application is finished.

1. After any inhalation exposure level listed on the product labeling has been reached or any WPS ventilation criteria have been met, you may permit workers into a treated area

Avoiding contact by during an REI if they will ***not*** **touch or be touched by** any pesticide residues, including: *using personal protective equipment does **not** qualify as no contact early entry.*

• **on plants**, including both agricultural plants and weeds, • **on or in soil** or planting medium,
• **in water**, such as irrigation water or water standing in drainage ditches or puddles,
• **in air**, if pesticide remains suspended after application, such as after fumigation or after a smoke, mist, fog, or aerosol application.

Employers must provide current and specific information about the pesticides being applied for the benefit of their employees (handlers and workers). Employees must be informed of the central location and allowed access.

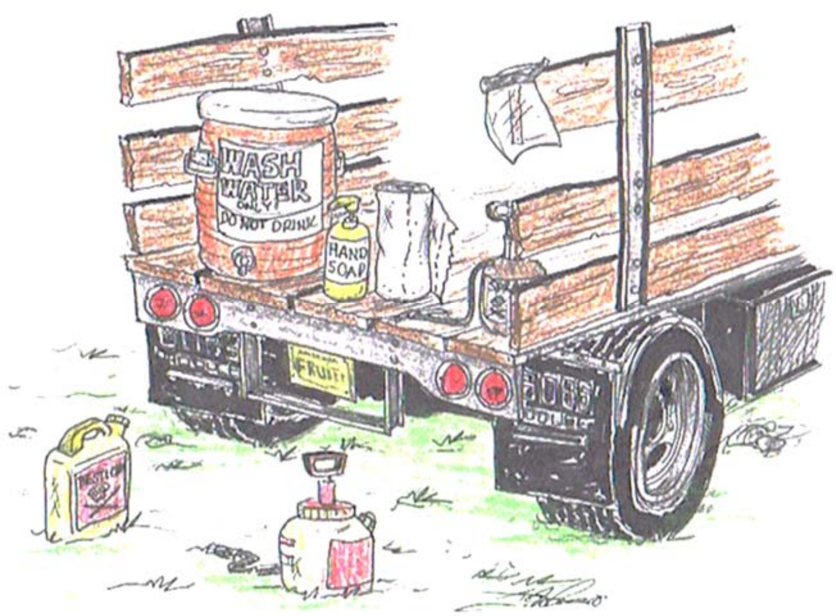
Employers (owner/operator of agricultural establishments) must post the following information just prior to applications and for 30 days after the REI has expired whenever pesticide handlers or workers are on the agricultural establishment:

- an approved EPA safety poster or an equivalent
- emergency medical information, including the name, address and telephone number of the nearest emergency medical care facility
- a list of dates and times that pesticides have been applied within the last 30 days, including a description of each treated area, and the product name, EPA registration number, active ingredient(s) and REI for each pesticide on that list

The information at the central location must be easily seen and read. Workers and handlers must be informed where it is and given access. By "access," the EPA wants the workers to be able to view the information without having to ask anyone to let them see it. Some examples of a central location include: field or forest entrance; parking area; common areas; break areas; port-a-pots. The central location cannot be in a treated area. The EPA safety poster or an equivalent needs to show how to keep pesticides from getting on or entering the body and information about how to clean up if an individual comes in contact with pesticides.

If the emergency medical information changes, update the posted information in the central location and ensure that it remains legible. Pesticide applications must remain on the list from before each application begins and remain posted through 30 days after the REI has expired. The list must remain accessible by the workers for the entire required posting period at the designated central location.

Handlers and workers must be informed of pesticide label requirements and information. A grower must have all the material safety data sheets (**MSDS**) of the labeled pesticides he/she is using on file and available upon request.



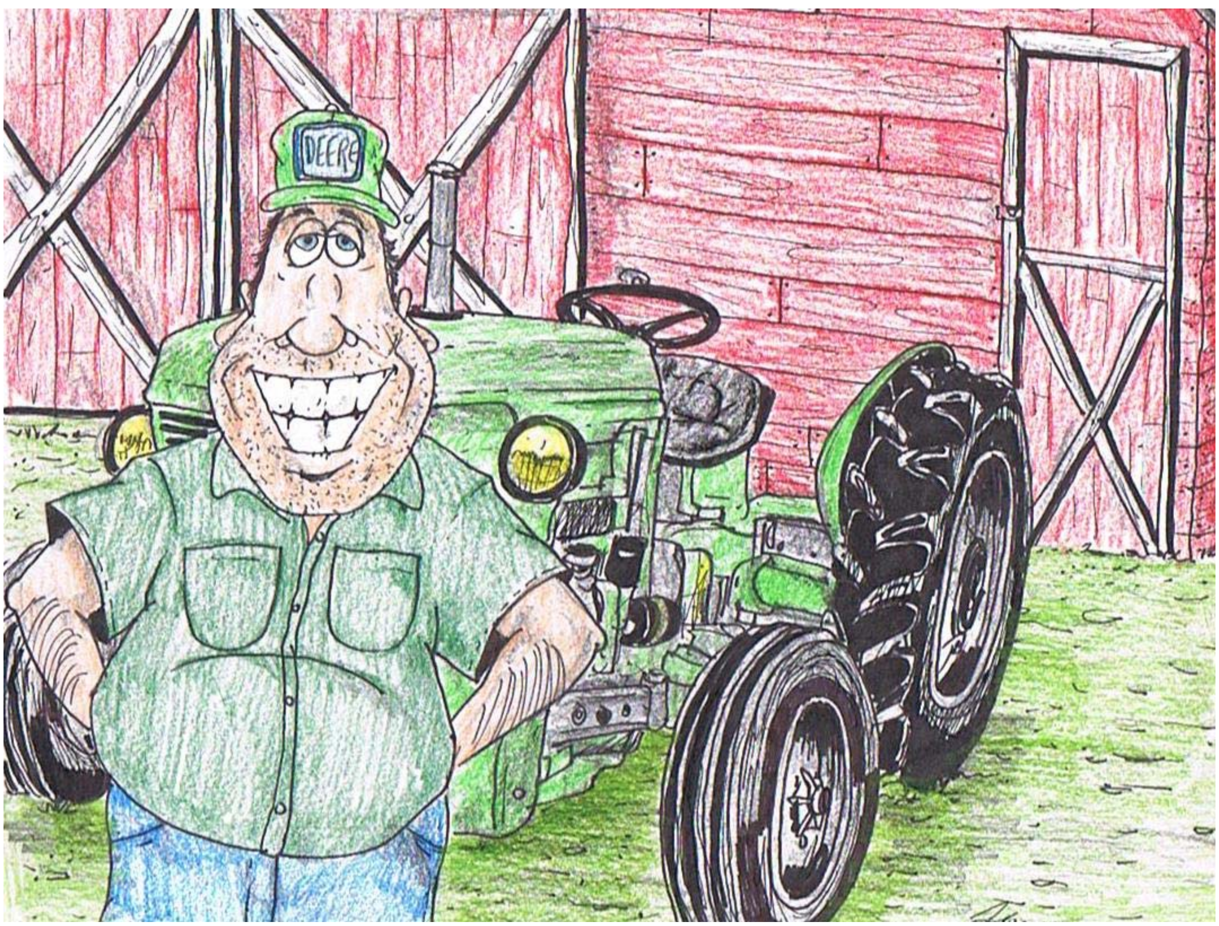
WPS Requires Providing Decontamination Sites
Employers must establish a decontamination site for all workers and handlers for washing off pesticides and pesticide residues. A decontamination site must be within a quarter (1/4) mile of the employees' work site.

Employers must provide a site where workers and handlers can wash pesticide residue from their hands and body. A decontamination site should supply:

- Enough water for routine and emergency whole body washing and for eye flushing.
- Plenty of soap and single use towels.
- Employers also must provide water that is safe and cool enough for washing, eye flushing, and drinking. Employers may not use tank stored water that also is used for mixing or diluting pesticides.

Specific requirements differ depending whether employees are doing worker or handler tasks. Worker decontamination site requirements:

- Decontamination sites must be provided for workers from application to 30 days after expiration of the REI.
- Worker decontamination sites may not be in areas being treated or under an REI.



No-contact early-entry workers do ***not*** have to be provided the special protections required in Early Entry. However, they must be provided the following protections offered to other agricultural workers: information at a central location, pesticide safety training for workers, notification, restrictions during applications and during restricted-entry intervals, and emergency assistance. Decontamination supplies, however, need ***not*** be provided to no- contact early-entry workers.

2. The following are examples of situations where a worker would ***not*** be expected to contact pesticide residues in a treated area after sprays, dusts, and vapors have settled out of the air:

- The worker is wearing footwear and is walking in aisles or on roads, footpaths, or other pathways through the treated area where the plants or other treated surfaces cannot brush against the worker and cannot drop or drip pesticides onto the worker.
- The worker is in an open-cab vehicle in a treated area where the plants cannot brush against the worker and cannot drop or drip pesticide onto the worker.
- After a pesticide application that is incorporated or injected into the soil, the worker is doing tasks that do not involve touching or disrupting the soil subsurface.
- The worker is in an enclosed cab on a truck, tractor, or other vehicle.

EARLY-ENTRY WORK SITUATIONS BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)
Worker employers must not allow their **workers** to enter treated areas where they will contact treated surfaces, except in a few very limited work situations.
Worker employers must provide special protections to any of their **workers** who do early-entry tasks involving contact with anything that has been treated with a pesticide, including soil, water, air, and surfaces of plants.

SPECIFIC DUTIES
Early entry involving contact with treated surfaces is permitted in only four work situations:
- **short-term tasks** that last less than 1 hour and do not involve hand labor,
- **limited-contact tasks** that could not have been foreseen, cannot be delayed, and do not involve hand labor,
- **emergency tasks** that take place because of an agricultural emergency, and
- **specific tasks** approved by EPA through a formal exception process.

Short-term Tasks With No Hand Labor
Workers may enter treated areas before the restricted-entry interval is over to do short-term jobs that do not involve hand labor, if provided with the protections and PPE required for early entry. Each worker must:
- Wait at least 4 hours after the pesticide application is completed before entering the treated area, ***and***
- Wait at least until any inhalation exposure level listed on the product labeling has been reached or any WPS ventilation criteria have been met, ***and***
- Spend no more than 1 hour in a 24-hour period on short-term early-entry tasks.

Hand Labor
Any agricultural activity performed by hand, or with hand tools, that might cause a worker to have substantial contact with surfaces (such as plants, plant parts, or soil) that may contain pesticide residues.

Examples of hand labor tasks include: harvesting, detasseling, thinning, weeding, topping, planting, girdling, caning, sucker removal, pruning, disbudding, roguing, and packing produce into containers in the field.

Limited-Contact Tasks
Tasks where early-entry workers' only contact with treated surfaces — including soil, water, surfaces of plants, crops, and irrigation equipment — is minimal and is limited to their feet, lower legs, hands, and forearms. Hand labor tasks are not limited-contact tasks.

Examples of limited-contact tasks include operating, moving, or repairing irrigation or watering equipment; operating or repairing weather monitoring and frost protection equipment; repairing greenhouse heating, air conditioning, and ventilation equipment; repairing non-application field equipment; maintaining and moving beehives.

Only appropriately trained and equipped pesticide handlers may operate, move, or repair the parts of chemigation equipment that may contain pesticide residues. Chemigation equipment is equipment used to apply pesticides with irrigation water.

Employers should make every effort to schedule pesticide applications and worker tasks in a way that will avoid the necessity of early entry of workers into treated areas.

Could not have been foreseen *means that when you made the pesticide application, you could not have anticipated the circumstances that led to the need to perform limited-contact tasks. For example, you do not qualify if you knew that you would need to enter the treated area to perform routine watering during the restricted-entry interval.*

Limited-Contact Tasks That Could Not Have Been Foreseen, Cannot Be Delayed, and Involve No Hand Labor

Early-entry workers may enter treated areas to do limited-contact tasks before the restricted-entry interval is over, provided **all the following conditions are met**:

• the early-entry tasks do **not** involve hand labor, ***and***

• the early-entry tasks will not cause workers to have more than minimal contact with treated surfaces, ***and***

• contact with treated surfaces will be limited to the workers' feet, lower legs, hands, and forearms, ***and***

• the need for the early-entry could not have been foreseen, ***and***

• if the early-entry tasks are delayed, the delay would cause significant economic loss, and there are no alternative practices that would prevent the loss, ***and***

• the pesticide product's Agricultural Use Requirement box does **not** contain the following "double notification" statement: "Notify workers of the application by warning them orally and by posting warning signs at entrances to treated area,"

and

• the pesticide product does **not** contain a restriction prohibiting any person, other than an appropriately trained and equipped handler, from entering during the restricted-entry interval.

You must provide each limited-contact early-entry worker with:

• either the personal protective equipment required on the pesticide labeling for early entry into treated areas *or* a standard set of PPE consisting of coveralls, chemical-resistant gloves, chemical-resistant footwear, and protective eyewear (and make sure the worker wears socks) ***and***

Note: You may eliminate the protective eyewear from the standard set of PPE in any treated area where the pesticide label does not require it for early entry.

• all the protections required for early-entry workers, ***and***

• oral or written notification, in a language that the workers can understand, that:

– the establishment is relying on this exception to allow workers to enter treated areas to complete limited-contact tasks,

– no entry is allowed for the first 4 hours after an application, and until applicable ventilation criteria have been met, and until any label-specified inhalation exposure level has been reached,

– the time the worker spends in any treated area where a restricted-entry interval is in effect cannot exceed 8 hours in any 24-hour period. You must make sure that each limited-contact early-entry worker:

• waits at least 4 hours after the pesticide application is completed before entering the treated area, ***and***

• waits at least until any inhalation exposure level listed on the product labeling has been reached or any WPS ventilation criteria have been met, ***and***
• spends no more than 8 hours in a 24-hour period on limited-contact early-entry tasks.

FURTHER REQUIREMENTS FOR EMPLOYERS OF WORKERS

Tasks During An Agricultural Emergency
Early-entry workers may enter treated areas before the restricted-entry interval is over to do tasks that are necessary because of an agricultural emergency, if provided with the protections and PPE required for early entry.

Each worker must:
• do only those tasks relating to mitigating the emergency, ***and***
• wait at least 4 hours after the pesticide application is completed before entering the treated area, ***and***
• wait at least until any inhalation exposure level listed on the product labeling has been reached or any WPS ventilation criteria have been met.

1. Declaring a Potential Agricultural Emergency
A state, tribal, or federal agency having jurisdiction must declare that circumstances exist, have occurred, or are forecast that might cause an agricultural emergency where your establishment is located. Such circumstances may include, for example, flooding, hail, high winds, hurricane, tornado, freeze, or frost.

2. Agricultural Emergency on Your Establishment
Once such an agency has declared that circumstances might cause (or might already have caused) an agricultural emergency in your area, you must decide if an agricultural emergency actually exists for any treated areas on your establishment that remain under a restricted-entry interval. **All of the following conditions must be met** before you may let workers go into a treated area where a restricted-entry interval is in effect:
• You could not have anticipated the circumstances that led to the emergency when you made the pesticide application. For example, you do not qualify if weather forecasts **before** the application warned you that the emergency was imminent.
• You had no control over the circumstances that led to the emergency. For example, you do not qualify if you forgot to heat your greenhouse or over- watered with an irrigation system.
• Early entry is the only practice that will prevent or reduce a substantial economic loss involving the crop in that treated area. For example, you do not qualify if you have access to mechanical harvesting equipment that could harvest your crop in lieu of hand-harvesting.
• If early entry does not occur, the loss of profit will be greater than the loss that would be expected on the basis of experience and the variation in crop yields in previous years. The contribution of mismanagement cannot be considered in determining the loss.

EPA-Approved Exceptions
EPA has established a formal regulatory process for considering additional exceptions to the restrictions on entering treated areas during an REI. If any such exceptions are approved, EPA will publish them in the Federal Register and intends to inform state and tribal pesticide agencies, the Cooperative Extension Service, affected commodity, industry, and worker associations, and other interested parties. Check with them or the EPA office in your region for an updated list of approved exceptions and for information about the requirements and limitations of those exceptions.

Respirator Storage

Respirators are to be stored as follows:

- All respirators shall be stored to protect them from damage, contamination, dust, sunlight, extreme temperatures, excessive moisture, and damaging chemicals, and they shall be packed or stored to prevent deformation of the face piece and exhalation valve.
- Emergency Respirators shall be:
- Kept accessible to the work area;
- Stored in compartments or in covers that are clearly marked as containing emergency respirators; and
- Stored in accordance with any applicable manufacturer instructions.

We will cover more in detail on respirators later

GENERAL PROTECTIONS FOR EARLY-ENTRY WORKERS BASIC RESPONSIBILITIES (See Also Specific Duties Section Below)

Worker employers must provide several types of protections, described below, to their **early-entry workers** who contact anything that has been treated with a pesticide, including soil, water, air, and surfaces of plants.

SPECIFIC DUTIES Protections Required By the Pesticide Labeling
Provide any protections required by the pesticide labeling for early-entry tasks.

Required Protections That Are the Same As For Other Workers
Provide protections that are required for all agricultural workers:

- Information at a central location,
- Emergency assistance,
- Restrictions during applications, and
- Notice about applications.

Special Protections For Early-entry Workers
A few WPS requirements for early-entry workers differ from those for other agricultural workers. Provide special protections to early-entry workers in the following areas:

- Training and instructions,
- Decontamination supplies, and
- Personal protective equipment.

TRAINING AND INSTRUCTIONS FOR EARLY-ENTRY WORKERS BASIC RESPONSIBILITIES
Worker employers must make sure that each of their **early-entry workers** is currently trained as a WPS worker and, in addition, receives specific information and instructions, described below.

SPECIFIC DUTIES Training
Make sure that each early-entry worker is currently trained as a WPS worker ***before*** entering a treated area on the agricultural establishment during a restricted-entry interval.

The 5-day grace period for training that applies to other agricultural workers does not apply to early-entry workers.

Instructions Related to Personal Protective Equipment (PPE)
Instruct early-entry workers, in a manner they can understand:

- how to put on, use, and take off early-entry PPE correctly,
- about the importance of washing thoroughly after removing PPE, and
- how to prevent, recognize, and give correct first aid for heat illness (too much heat stress).

Labeling Information and Instructions
Inform early-entry workers, in a manner they can understand, about the safety *i*nformation and instructions on the labeling of the pesticide(s) to which the REI applies, *workers who will do* including:

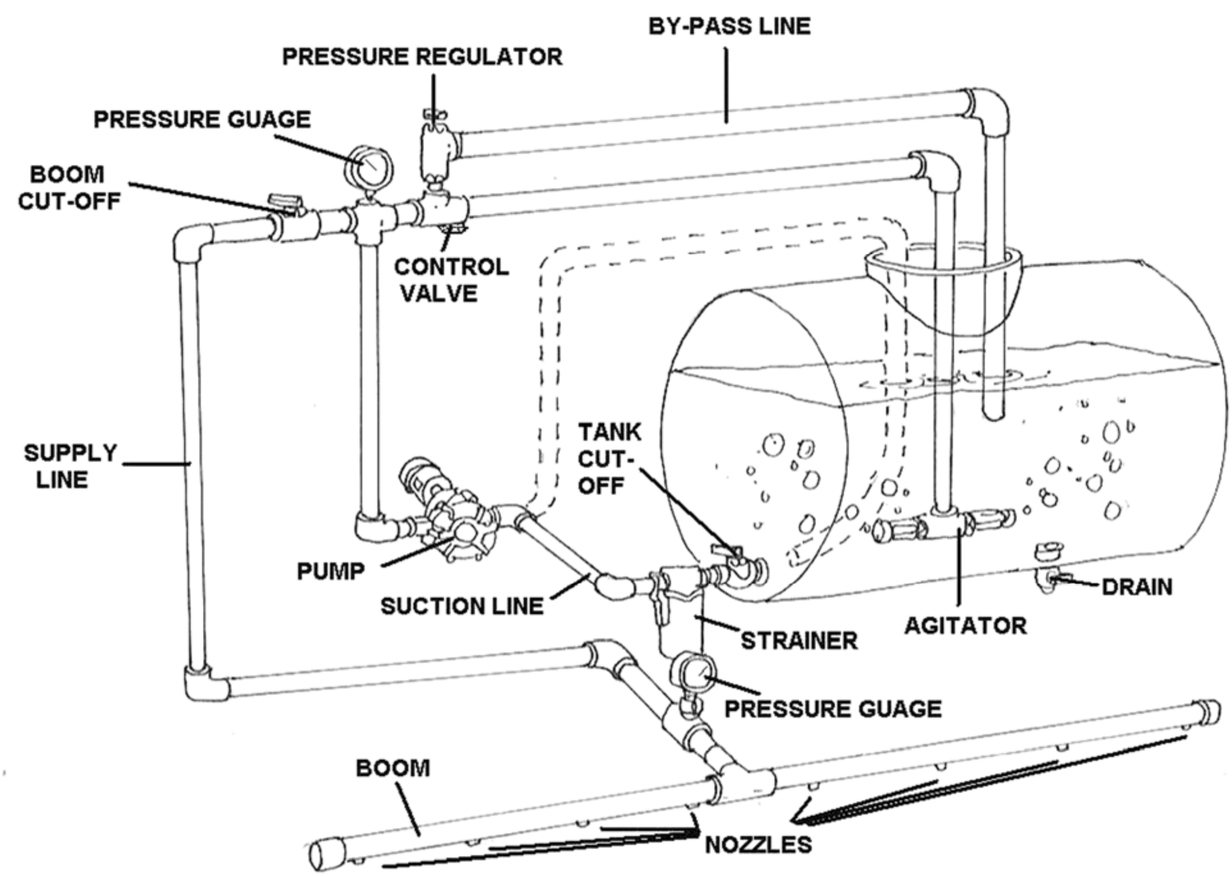
- human hazard statements and precautions,

- first aid, *themselves,*
- signs and symptoms of poisoning,
- PPE required for early entry, and
- any other precautions or instructions related to safe use or early entry.

Option: You may allow early-entry tasks to read the labeling if they are able to read and understand it.

***Decontamination and emergency eyeflush water** must, at all times when it is available to early-entry workers, be of a quality and temperature that will not cause illness or injury when it contacts the skin or eyes or if it is swallowed.*

TYPICAL BOOM SPRAYER



DECONTAMINATION SUPPLIES FOR EARLY-ENTRY WORKERS BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)

Worker employers must provide their **early-entry workers** with decontamination supplies for washing off pesticides and pesticide residues.

SPECIFIC DUTIES Supplies

Provide early-entry workers with:

1. Water — enough for:

- routine washing, and
- emergency eyeflushing. If the water is stored in a tank, the water ***must not*** be used for mixing pesticides, unless the tank is equipped with correctly functioning antibacksiphoning or check valves or other mechanisms (such as air gaps) that prevent pesticides from moving into the tank.

2. Soap and single use towels — enough for the needs of early-entry workers.

Recommendation: How Much Water Should Be Provided?

Obviously, running water meets the requirement. However, if it is not available, use the following guidelines.

- **Early-Entry Workers:** At least 1 gallon of water is recommended for each early-entry worker using the supplies. If you find that 1 gallon per early-entry worker is inadequate to last for the entire work period, provide more water or replenish the water as needed during the work period.

Location

Make sure:

1. The decontamination supplies are ***not*** in an area being treated with pesticides.
2. The decontamination supplies are ***not*** in an area under a restricted-entry interval, ***unless*** that location is necessary for the supplies to be reasonably accessible to early-entry workers.
3. The decontamination supplies are reasonably accessible to and not more than 1/4 mile from early-entry workers.

Exception

For tasks performed more than 1/4 mile from the nearest point reachable by vehicle (car, truck, or tractor), the decontamination supplies may be at the access point. In this circumstance, clean water from springs, streams, lakes, or other sources may be used for decontamination if such water is more readily available than the water at the access point.

Emergency Eyeflushing

Provide each early-entry worker with at least 1 pint of emergency eyeflush water when the pesticide labeling requires protective eyewear for early entry. The emergency eyeflush water must be **immediately accessible**. For example, it could be carried by the handler or be on a vehicle the early-entry worker is using. The water that is supplied for general decontamination may also be used as eyeflush water, if it is immediately accessible.

Decontamination at the End of Exposure Period
At the site where early-entry workers take off their PPE, provide :

- soap,
- clean towels, and
- enough water to allow early-entry workers to wash thoroughly after removing their PPE.

PPE for early-entry activities is listed on the pesticide label in the “Directions for Use” section under the heading “Agricultural Use Requirements.”

PERSONAL PROTECTIVE EQUIPMENT FOR EARLY-ENTRY WORKERS
BASIC RESPONSIBILITIES

Worker employers must provide their **early-entry workers** with the early-entry PPE required by the pesticide labeling, make sure they wear the PPE, and make sure they use the PPE correctly.

SPECIFIC DUTIES Duties Related to Personal Protective Equipment
1. Provide the appropriate PPE in clean and operating condition to each early-entry worker.
2. Make sure early-entry workers wear PPE correctly for its intended purpose and use it according to the manufacturer's instructions.
3. Inspect all PPE before each day of use for leaks, holes, tears, or worn places. Repair or discard any damaged equipment.
4. Provide early-entry workers clean places away from pesticide storage and pesticide use areas to:
    - store personal clothing not in use,
    - put on PPE at the start of any exposure period, and
    - take off PPE at the end of any exposure period.
5. Take necessary steps to prevent heat illness (too much heat stress) while PPE is being worn.
6. Do not allow early-entry workers to wear home or take home PPE contaminated with pesticides.

Cleaning and Maintaining PPE
1. Keep pesticide-contaminated PPE separate from other clothing or laundry, and wash it separately.
2. If PPE will be reused, clean it before each day of reuse according to the instructions from the PPE manufacturer, unless the pesticide labeling specifies different requirements. If there are no such instructions or requirements, wash the PPE thoroughly in detergent and hot water.
3. Thoroughly dry the clean PPE before it is stored, or put it in a well-ventilated place to dry.
4. Store clean PPE separately from personal clothing and away from pesticide-contaminated areas.

Disposal of PPE
Comply with any applicable federal, state, tribal, and local regulations when you dispose of PPE that cannot be cleaned correctly.

Instructions for Persons Who Clean PPE
Inform anyone who cleans or launders PPE:
- that PPE may be contaminated with pesticides,
- of the potentially harmful effects of pesticides,
- how to protect themselves when handling contaminated PPE, and
- how to clean PPE correctly. For more information about laundering pesticide-contaminated clothing, please visit the

Worker Protection Standard topic page on the Ag Center's Web site.

FURTHER REQUIREMENTS FOR EMPLOYERS OF HANDLERS RESTRICTIONS DURING APPLICATIONS AND MONITORING HANDLERS
BASIC RESPONSIBILITIES

Handler employers must make sure that:
• pesticides do not touch **people**, other than appropriately trained and equipped handlers, during pesticide applications, and
• **pesticide handlers** are monitored, as described below, when handling certain types of pesticides. **Pesticide handlers** must make sure that pesticides do not touch **people**, other than appropriately trained and equipped handlers, during pesticide applications.

SPECIFIC DUTIES Restrictions During Applications
Both handler employers and pesticide handlers must make sure that each pesticide is applied so that it does not contact, either directly or through drift, anyone except appropriately trained and equipped handlers.

Monitoring Handlers
1. Pesticides with skull and crossbones
At least once every 2 hours, someone must check on — by sight or by voice communication — any handler who is handling a pesticide that has a skull and cross bones symbol on its label. (For monitoring the handling of fumigants in greenhouses, see immediately below.)
2. Fumigants handled in greenhouses
Someone must maintain constant visual or voice contact with any handler who is applying or otherwise handling a fumigant in a greenhouse. This includes handlers who enter the greenhouse during fumigation to operate ventilation systems, adjust tarps or other coverings used in the fumigation, or check air concentration levels. The person monitoring the fumigant handler must:

- be trained as a pesticide handler, and
- have immediate access to the PPE that the fumigant labeling requires for applicators.

Fumigant
Any pesticide product that is a vapor or gas, or forms a vapor or gas on application, and whose method of pesticidal action is through the gaseous state.

Option: You may allow handlers to read the labeling themselves, if they are able to read and understand it.

Operators of agricultural establishments are required to make sure that commercial handler employers have this information.

SPECIFIC INSTRUCTIONS FOR HANDLERS
BASIC RESPONSIBILITIES (See Also Specific Duties Section Below)

Handler employers must make sure that, before **handlers** do any handling task, the handlers:

- are given information from the pesticide labeling and have access to the labeling itself, and
- are instructed in the safe operation of the equipment they will be using.

Commercial (custom) handler employers must make sure that, whenever one of their handlers will be doing pesticide handling tasks (including tasks as a crop advisor) on an agricultural establishment, he or she is aware of specific information, described below, concerning pesticide-treated areas on the agricultural establishment.

SPECIFIC DUTIES Labeling Access and Information

1. Inform handlers, in a manner they can understand, about all labeling requirements related to safe use of the pesticide, including at least:
   - the signal word,
   - human hazard statements and precautions,
   - personal protective equipment requirements,
   - first aid instructions,
   - environmental precautions, and
   - any additional precautions about the handling task to be performed.
2. Provide handlers access to the pesticide labeling information during handling tasks.

Safe Operation of Equipment

Make sure that handlers know how to safely and correctly use all equipment they are assigned to use for handling pesticides, including, if applicable, how to avoid drift and how to use chemigation equipment safely.

Instructions for Commercial Pesticide Handlers

Commercial (custom) pesticide handler employers must make sure that their handler employees are informed about:

1. Specific location and description of any areas on the agricultural establishment:
   - that may be treated with a pesticide or be under a restricted-entry interval while the commercial handler will be there, ***and***
   - that the commercial handler may be in (or walk within 1/4 mile of).

2. Restrictions on entering those areas.

For example, if custom applicators are scheduled to use ground equipment to apply a pesticide on a farm, they need to be informed of any nearby areas on the farm that they should stay out of because the area has an REI in effect. Or if commercial crop advisors are scheduled to scout in an area on a farm that remains under an REI, they need to be told what personal protective equipment they must wear while in that area.

FURTHER REQUIREMENTS FOR EMPLOYERS OF HANDLERS
EQUIPMENT SAFETY
BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)
Handler employers must make sure that equipment used for mixing, loading, transferring, or applying pesticides (pesticide handling equipment) is inspected and repaired and that **persons repairing, cleaning, or adjusting** such equipment are protected or informed, as described below.

SPECIFIC DUTIES Equipment Inspection
Inspect pesticide handling equipment before each day of use for leaks, clogging, and worn or damaged parts. Repair or replace any damaged equipment.

Protections for Persons Maintaining Equipment
Remove pesticide residues from pesticide handling equipment before anyone other than an appropriately trained and equipped handler is allowed to repair, clean, or adjust it.

Exception
If it is not feasible to remove pesticide residues from pesticide handling equipment, and the people who will be repairing, cleaning, or adjusting the equipment are not your employees (and, therefore, are not handlers for whom you are responsible under the WPS), you must inform them:

- that the equipment may be contaminated with pesticides,
- of the potentially harmful effects of exposure to pesticides, and
- how to correctly handle such equipment.

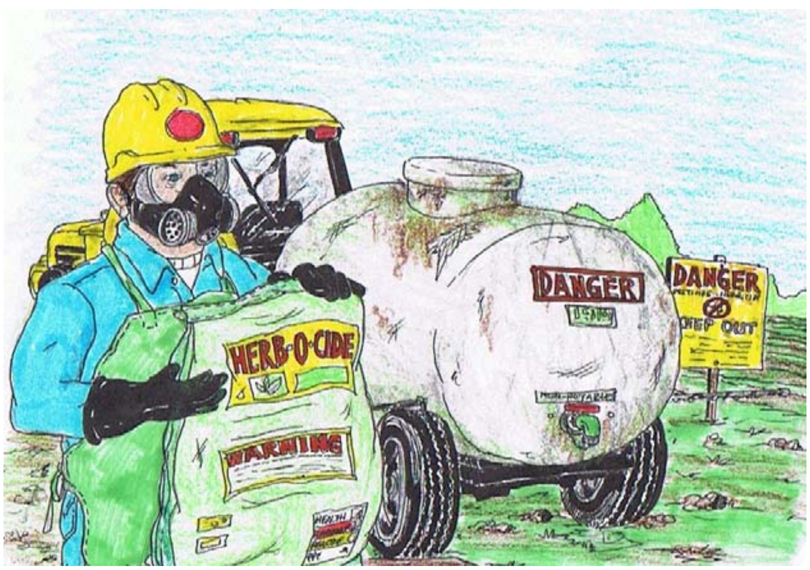
In the pesticide labeling, PPE for handling activities is listed in the "Hazards to Humans" section.

Why Rinse Pesticide Containers?

Proper rinsing of pesticide containers is easy to do, saves money, and helps protect people and the environment. It also helps prevent potential problems with un-rinsed containers, rinsate storage, and pesticide wastes. Even during a busy season the few extra minutes it takes to properly rinse empty pesticide containers is time well spent.

- Rinsate from the containers, when added directly into the sprayer tank, efficiently and economically uses all pesticide in the container. This eliminates the need to store and later dispose of the rinsate.
- Unless rinsed from the container immediately, some pesticides will solidify and become difficult to remove.
- Rinsing containers removes a potential source of pesticide exposure to people, animals, and wildlife.
- Proper rinsing is required by federal and state regulations and is a good, sound agricultural and environmental practice.

Rinsing Helps Protect the Environment
Proper rinsing of pesticide containers reduces a potential source of contamination of soil, surface, and ground water. When contamination occurs, plants and animals may be harmed and water supplies affected. Prevention of environmental contamination is always better than cleanup. Rinsing also helps in reducing the problem of handling pesticide wastes.



No matter how an empty pesticide container is disposed of, **it must be properly rinsed and triple punched.**

Both federal and state laws require rinsing. Landfill operators and recyclers can only accept properly rinsed containers. Pesticide containers should only be offered to recycling projects designed for pesticide containers and not general plastic and metal recycling programs. Pesticide container recycling project personnel will inspect containers to determine if they have been properly rinsed.

Rinsing is Effective
Pesticide residues measured in selected containers that passed visual inspection in the test project show rinsing at the time of use is effective:

Percent of pesticide residue removed with proper rinsing		
Pesticide	**Container**	**% Removal**
2, 4-D	2.5 gallon plastic	99.9999
pendimethalin	2.5 gallon plastic	99.9969
alachlor	5.0 gallon metal	99.9998
glyphosate	1.0 gallon plastic	99.9989
metolachlor	2.5 gallon plastic	99.9999
carbofuran	2.5 gallon plastic	99.9993

Types of Pesticide Containers
Currently the most common agricultural pesticide container is a 2.5 gallon plastic jug. Agricultural, animal, household, and other pesticide products also come packaged in glass, paper, metal and aerosol cans. Many liquid agricultural pesticides are also sold in returnable bulk containers and mini-bulk containers. Only plastic, glass and un-pressurized metal containers can be rinsed. Ease of handling and proper disposal should be considered when purchasing pesticides.

How to Properly Rinse
Two different procedures are effective for proper rinsing of pesticide containers: pressure-rinsing and triple-rinsing.

Pressure-Rinsing
A special nozzle is attached to the end of a hose to force the remaining pesticide from the container. Pressure-rinsing, which may be faster and easier than triple-rinsing, can be used with plastic and non-pressurized metal pesticide containers.

How to Pressure-Rinse
1. Remove cover from container. Check cover and container threads for pesticide. Rinse covers separately in a bucket of water for more than one minute and pour this rinse water into the spray tank.
2. Empty pesticide into the spray tank and let container drain for 30 seconds.
3. Insert pressure-nozzle by puncturing through the lower side of the pesticide container.
4. Hold the container upside down over the sprayer tank opening so rinsate will run into the sprayer tank.
5. Rinse for length of time recommended by the manufacturer (generally 30 seconds or more). Wiggle nozzle to rinse all inside surfaces. Be sure hollow handles are well rinsed.
6. Let container dry and then put cover back on container.

Triple-Rinsing

It means rinsing the container three times. Triple-rinsing can be used with plastic, non-pressurized metal, and glass containers.

How to Triple-Rinse

1. Remove cover from the container.
2. Empty the pesticide into the sprayer tank and let the container drain for 30 seconds.
3. Fill the container 10% to 20% full of water or rinse solution.
4. Secure the cover on the container.
5. Swirl the container to rinse all inside surfaces.
6. Remove cover from the container. Add the rinsate from the container to sprayer tank and let drain for 30 seconds or more.
7. Repeat steps 2 through 5 **two more times.**
8. Let container dry and then put cover back on container. Triple punch the bottom.

Remember

- To read and to follow all label instructions.
- To wear appropriate protective gear when working with pesticides.
- Never reuse a pesticide container for any purpose.
- To dispose of all pesticide containers properly.
- When not using a water nurse tank, always use a back-flow prevention device when filling sprayer tanks or rinsing pesticide containers.
- Mixing and loading sites should be at least 150 feet away from all wells.

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The fate of pesticides released into the environment is unknown. Releases may be followed by a very complex series of events which can transport the pesticide through the air or water, into the ground or even into living organisms. The medium for movement (air, water, soil, organisms) and the degree of movement (local or long distance distribution) will be different for each pesticide.

PERSONAL PROTECTIVE EQUIPMENT (PPE) BASIC RESPONSIBILITIES

(See Also Specific Duties Section Below)
Handler employers must make sure that **pesticide handlers**:

- are provided with the PPE the pesticide labeling requires for the task,
- wear the PPE for the entire handling task, and
- use the PPE correctly. **Each pesticide handler** is responsible for wearing the required personal protective equipment during the entire handling task.

SPECIFIC DUTIES Duties Related to Personal Protective Equipment
Employers must:
1. Provide handlers with the appropriate PPE in clean and operating condition.
2. Make sure the handlers wear the PPE correctly and use it according to the manufacturer's instructions. If a handler wears a respirator, make sure that it fits the wearer correctly.
3. Inspect all PPE before each day of use for leaks, holes, tears, or worn places, and repair or discard any damaged equipment.
4. Provide handlers with clean places away from pesticide storage and pesticide use areas to:
    - store personal clothing not in use,
    - put on PPE at the start of any exposure period,
    - take off PPE at the end of any exposure period.
5. Take any necessary steps to prevent heat illness (too much heat stress) while PPE is being worn.
6. Do not allow any handler to wear home or take home PPE contaminated with pesticides.

Cleaning and Maintaining PPE
Employers must do the following:

1. Keep pesticide-contaminated PPE away from other clothing or laundry, and wash it separately.

2. If PPE will be reused, clean it before each day of reuse according to the instructions from the PPE manufacturer unless the pesticide labeling specifies other requirements. If there are no such instructions or requirements, wash PPE thoroughly in detergent and hot water.

3. Thoroughly dry the clean PPE before it is stored, or put it in a well-ventilated place to dry.

4. Store clean PPE separately from personal clothing and away from pesticide-contaminated areas.

FURTHER REQUIREMENTS FOR EMPLOYERS OF HANDLERS
Replacing Respirator Filters, Cartridges, or Canisters

Employers must:

1. Replace dust/mist respirator filters:
   - when breathing resistance becomes excessive,
   - if the filter is damaged or torn,
   - whenever the respirator manufacturer or pesticide labeling says to replace them (if the instructions differ, change the filter at the shorter interval),
   - at the end of each day's work period, if no other instructions or indications of service life are available.

2. Replace gas- and vapor-removing respirator cartridges or canisters:
   - at the first indication of odor, taste, or irritation,
   - when the respirator manufacturer or pesticide labeling says to replace them (if instructions differ, change the cartridge or canisters at the shorter interval),
   - at the end of each day's work period, if no other instruction or indications of service life are available.

Disposal of PPE
Employers must:

1. Discard coveralls or other absorbent materials that have been drenched or heavily contaminated with an undiluted pesticide that has the signal word "DANGER" or "WARNING" on the labeling. They must not be reused.

2. Comply with any applicable Federal, State, Tribal, and local regulations when disposing of PPE that cannot be cleaned correctly.

Instructions for Persons Who Clean PPE
Employers must inform people who clean or launder PPE:
- that the PPE may be contaminated with pesticides,
- of the potentially harmful effects of exposure to pesticides,
- how to protect themselves when handling contaminated PPE, and
- how to clean PPE correctly. For more information about laundering pesticide-contaminated clothing, please visit the Worker Protection Standard topic page on the Ag Center's Web site.

Personal Protective Equipment (PPE) Definitions

Personal Protective Equipment:
Apparel and devices worn to protect the body from contact with pesticides or pesticide residues, including: coveralls, chemical-resistant suits, gloves, footwear, aprons, and headgear, protective eyewear, and respirators. *While the following attire is not defined as PPE, the labeling may require pesticide handlers or early-entry workers to wear it for some tasks: long- and short-sleeved shirts, long and short pants, shoes and socks, other items of regular work clothing. If such non-PPE attire is required, the employer must make sure that it is worn.*

Chemical-resistant:
Allows no measurable amount of the pesticide being used to move through the material during use.

Waterproof:
Allows no measurable movement of water (or water-based solutions) through the material during use.

Chemical-resistant footwear:
Chemical-resistant shoes; chemical-resistant boots; or chemical-resistant shoe coverings worn over shoes or boots. *Substitution:* Leather boots may be worn in rough terrain, if chemical-resistant footwear with sufficient durability and a tread appropriate for wear in such terrain is not obtainable.

Protective eyewear:
Goggles, a face shield, or safety glasses with front, brow, and temple protection. *Substitution:* A full-face respirator may be worn instead of protective eyewear.

Chemical-resistant suit:
A loose-fitting, one- or two-piece, chemical-resistant garment that covers, at a minimum, the entire body except head, hands, and feet.

Coverall:
A loose-fitting one- or two-piece garment that covers, at a minimum, the entire body except head, hands, and feet. Coveralls are made of fabric such as cotton or a cotton-polyester blend, and are not chemical-resistant. The pesticide labeling may specify that the coveralls be worn over a layer of clothing. *Substitution:* A chemical-resistant suit may be worn instead of coveralls and any required inner layer of clothing.

Chemical-resistant apron:
An apron that is made of chemical-resistant material and that covers the front of the body from mid-chest to the knees. *Substitution:* If a chemical-resistant suit is worn, no apron is required.

Respirator:
A device that protects the respiratory system. It must be the type listed on the pesticide label (or one that is more protective) and must be appropriate for the pesticide product being used and for the activity being performed. *Substitutions:* A respirator with a canister

approved for pesticides or with an organic-vapor cartridge equipped with a pesticide prefilter may be worn instead of a dust/mist filtering respirator.

Chemical-resistant headgear:
A chemical-resistant hood or a chemical-resistant hat with a wide brim.

Gloves:
Hand-coverings that are the type listed on the pesticide label.

• Gloves made of leather, cotton, or other absorbent materials **must not be worn** for handling or early-entry activities unless these materials are listed on the pesticide labeling as acceptable for such use.

• Chemical-resistant gloves with non-separable absorbent lining materials **must not be worn** for handling or early-entry activities.

• *Substitution:* Leather gloves may be worn over chemical-resistant liners, if chemical-resistant gloves with sufficient durability and suppleness are not obtainable. However, after leather gloves have been worn for protection from pesticide exposure, they may only be worn with chemical-resistant liners and may not be worn for any other use.

Separable glove liners:
Separable glove liners are separate glove-like hand coverings, made of lightweight material, with or without fingers.

• Work gloves made from lightweight cotton or poly-type material are considered to be glove liners, if worn beneath chemical-resistant gloves.

• Unless the pesticide product labeling specifically prohibits their use, separable glove liners may be worn beneath chemical-resistant gloves, *provided* the liners do not extend outside the chemical-resistant gloves that are worn over them.

• Once used for handling or early-entry activities, separable glove liners **must be discarded immediately** after a total of 10 hours of use **or** within 24 hours of first use, whichever occurs first. The liners **must be replaced immediately** if they come into direct contact with pesticides. Pesticide- contaminated liners must be disposed of in accordance with any federal, state, or local regulations.

These exceptions to PPE are allowed unless expressly prohibited by product labeling. Even when reduced PPE is permitted to be worn during a task, handlers must be provided all PPE required by the pesticide labeling for that task and have it immediately available for use in an emergency.

Personal Protective Equipment

EPA Chemical Resistance Category Chart
For use when PPE section on the pesticide label lists a chemical resistance category.
The Worker Protection Standard requires that labels of pesticides used on farms, and in forests, nurseries and greenhouses list the type of personal protective equipment (PPE) that must be worn with each product. Labels will refer to chemical resistance categories (A-H) for PPE. Items in these categories are made of materials that the pesticide cannot pass through during the times indicated below the chart. Choose the category of resistance which best matches the handling task duration. The categories are based on the solvents used in the pesticides, NOT the pesticides themselves. Therefore, there will be instances where the same pesticide with two different formulations (wettable powder-WP and emulsifiable concentrate-EC, for example) will require PPE from two different chemical resistance categories.

Selection Category Listed on Pesticide Label	**Types of Personal Protective Material**							
	Barrier Laminate	Butyl Rubber ≥ 14 mils	Nitrile Rubber ≥ 14 mils	Neoprene Rubber ≥ 14 mils	Natural Rubber ≥ 14 mils	Polyethelene	Polyvinyl Chloride (PVC) ≥ 14 mils	Viton ≥ 14 mils
A(a dry and water-based formulation)	high	high	high	high	high	high	high	high
B	high	high	slight	slight	none	slight	slight	slight
C	high	high	high	high	moderate	moderate	high	high
D	high	high	moderate	moderate	none	none	none	slight
E	high	slight	high	high	slight	none	moderate	high
F	high	high	high	moderate	slight	none	slight	high
G	high	slight	slight	slight	none	none	none	high
H	high	slight	slight	slight	none	none	none	high

HIGH: Highly chemical-resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticides at rest breaks.

MODERATE: Moderately chemical-resistant. Clean or replace PPE within an hour or two of contact.

SLIGHT: Slightly chemical-resistant. Clean or replace PPE within ten minutes of contact.

NONE: No chemical-resistance. Do not wear this type of material as PPE when contact is possible.

Entry-Restricted Areas in Nurseries During Pesticide Applications

During Application of a Pesticide	Workers and other persons are Prohibited In:
(1)(a) Applied: aerially, in an upward direction, or using a spray pressure greater than 150 psi (pounds per square inch), or (b) Applied as a: fumigant, smoke, mist, fog, or aerosol	Pesticide treated area plus 100 feet in all directions on the nursery
(2)(a) Applied downward using: a height of greater than 12 inches from the planting medium, a fine spray, or a spray pressure greater than 40 psi and less than 150 psi. (b) Not as in 1 or 2(a) above, but for which a respiratory protection device is required for application by the product labeling	Treated area plus 25 feet in all directions on the nursery
(3) Applied otherwise	Pesticide treated area

READ THE SAFETY DATA SHEET

WEAR PROPER PPE

HANDLING CHEMICALS

Interpreting PPE Statements on Pesticide Labels

Label Statement	Acceptable PPE
Long-sleeved shirt and	Long-sleeved shirt and long pants long pants, or Woven or nonwoven coverall Plastic- or other barrier-coated coverall, or Rubber or plastic suit
Coverall worn over short-sleeved shirt and short pants	Coverall worn over short-sleeved shirt and short pants, or Coverall worn over long-sleeved shirt and long pants, or Coverall worn over another coverall, or Plastic-or other barrier-coated coverall, or Rubber or plastic suit
Coverall worn over long-sleeved shirt and long pants	Coverall worn over long-sleeved shirt and long pants, or Coverall worn over another coverall, or Plastic- or other barrier-coated coverall, or Rubber or plastic suit
Chemical-resistant apron worn over coverall or over long-sleeved shirt and long pants	no substitute
Waterproof suit or liquidproof suit	no substitute
Waterproof gloves	Any rubber or plastic gloves sturdy enough to remain intact throughout the task being preformed
Chemical-resistant gloves	Barrier-laminate gloves, or Other gloves that glove selection charts or guidance indicate are chemical-resistant to the pesticide for the period of time required to perform the task
Chemical-resistance gloves such as butyl or nitrile	Butyl gloves, or nitrile gloves, or Other gloves that glove selection charts or guidance indicate are chemical-resistant to the pesticide for the period of time required to perform the task
Shoes	Leather, canvas, or fabric shoes chemical-resistant shoes, or chemical-resistant boots, or chemical-resistant shoe coverings (booties)
Chemical-resistant footwear	Chemical-resistant shoes, or Chemical-resistant boots, or Chemical-resistant shoe coverings (booties)
Chemical resistant boots	Chemical-resistant boots

Chemical-resistant hood or wide-brimmed hat	Rubber- or plastic-coated safari-style hat or fire-fighter hat, or plastic- or other barrier-coated hood, or rubber or plastic hood Full hood or helmet that is part of some respirators.

To avoid harm from the pesticide, you should:
• Pour the clothes from their container into the washer without touching them.
• Handle only the inner surfaces, such as the inside of boots, aprons, or coveralls.
• Do not breathe the steam from the washer and dryer.

Always follow the label's instructions no matter the case or what you think might work. Applicators go to jail and are given large fines for not following the label.

You should wear work clothing that protects your body from pesticide residues, such as long-sleeved shirts, long pants, shoes, and socks. If possible, avoid touching the parts of the equipment where the pesticide is most likely to be. Or, if practical for the job that you will be doing, consider wearing rubber or plastic gloves and an apron.

You should not let pesticides stay on your hands:
• Wash your hands as soon as you finish handling the equipment.
• Wash your hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
• Wash or shower with soap and water, shampoo your hair, and put on clean clothes after work.
• Wash work clothes that may have pesticides on them separately from other clothes before wearing them again.

Federal Pesticide Recordkeeping Requirements

Questions and Answers
Final regulations to implement requirements in section 1491 of the Food, Agriculture, Conservation, and Trade (**FACT**) Act of 1990, commonly referred to as the 1990 Farm Bill, went into effect **May 10, 1993.** On February 10, 1995 amendments to the regulations were published, which become effective on May 11, 1995. The regulations are administered by the U.S. Department of Agriculture's Agricultural Marketing Service (**AMS**).

Why are there regulations for restricted use pesticide recordkeeping for certified private applicators? The FACT Act of 1990, subtitle H, section 1491, states that the Secretary of Agriculture, in consultation with the Administrator of the Environmental Protection Agency (**EPA**), ***"shall require certified applicators of restricted use pesticides..... to maintain records comparable to records maintained by commercial applicators of pesticides in each State."*** Certified applicators include both commercial and private applicators. The EPA currently requires certified commercial applicators to keep records under regulations implementing the Federal Insecticide, Fungicide, and Rodenticide Act (**FIFRA**). The EPA is prohibited from requiring certified private applicators to maintain records. However, some individual States require certified private applicators to maintain records.

Do the regulations apply to all pesticide applications? No. The regulations only require recordkeeping for applications of federally-restricted use pesticides. Pesticides are classified as restricted use, general use, or for both uses.

Is a Federal form required for maintaining the record(s)? No. The regulations do not require the use of a standardized form. This allows applicators the flexibility to fit the recordkeeping requirements into their current recordkeeping scheme.

What information is a certified private applicator required to maintain on a restricted use pesticide application? The recordkeeping requirements are:

1. The brand or product name, and the EPA registration number of the restricted use pesticide that was applied;
2. The total amount of the restricted use pesticide applied;
3. The location of the application, the size of area treated, and the crop, commodity, stored product, or site to which a restricted use pesticide was applied;
4. The month, day, and year when the restricted use pesticide application occurred; and
5. The name and certification number (if applicable) of the certified applicator who applied or who supervised the application of the restricted use pesticide.

When does the pesticide application information have to be recorded? The information required shall be recorded within 14 days following the pesticide application.

How long are records required to be kept? Restricted use pesticide records must be retained by the applicator for 2 years from the date of application and made available to individuals who are authorized to have access to the record information.

Certified applicators have no reporting requirements under the regulations.

Who has authorization to obtain record information from the certified applicator? Individuals representing the Secretary of Agriculture or the State designated agency, which is most commonly the State Department of Agriculture. Also the attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, is authorized access to record information when it is determined the information is needed to provide medical treatment or first aid to an individual who may have been exposed to the restricted use pesticide for which the record is maintained.

Are there any penalties for violation of the Federal pesticide recordkeeping requirements? Yes. Any certified applicator who violates the requirements shall be subject to a civil penalty of not more than $500 in the case of the first offense, and shall be subject to a civil penalty of not less than $1000 for each violation for subsequent offenses, except that the civil penalty shall be less than $1000 if the Administrator determines that the certified applicator made a good faith effort to comply.

AMENDMENTS TO THE REGULATIONS - EFFECTIVE MAY 11, 1995

1. **Change in the way the location of a "spot application" is recorded.**
   A" spot application" is an application(s) of a restricted use pesticide made on the same day in a total area of less than one-tenth of an acre. This provision still does not apply to records maintained for greenhouse and nursery applications.

   The regulations were amended to require a more detailed description of the location of a ***"spot application."*** Spot applications must be recorded with the following information: Brand or product name and EPA registration number; total amount applied; location must be designated as ***"spot application,"*** followed by a concise description of the location (**Examples:** Spot application, noxious weeds were spot sprayed throughout field number 5 and 6. Spot application, sprayed for weeds next to the silo); and month, day, and year of application.

2. **Shortened the time period to make a record of the restricted use pesticide application.**
   The time period was reduced from 30 days to 14 days for the required information to be legibly recorded following the restricted use pesticide application.

   However, whether or not the written record has been completed, the certified applicator shall provide the record information for medical treatment or first aid.

3. **Change in the definition of a medical emergency.**
   A medical emergency is defined as a situation that requires immediate medical treatment or first aid to treat possible symptoms of pesticide poisoning or exposure.

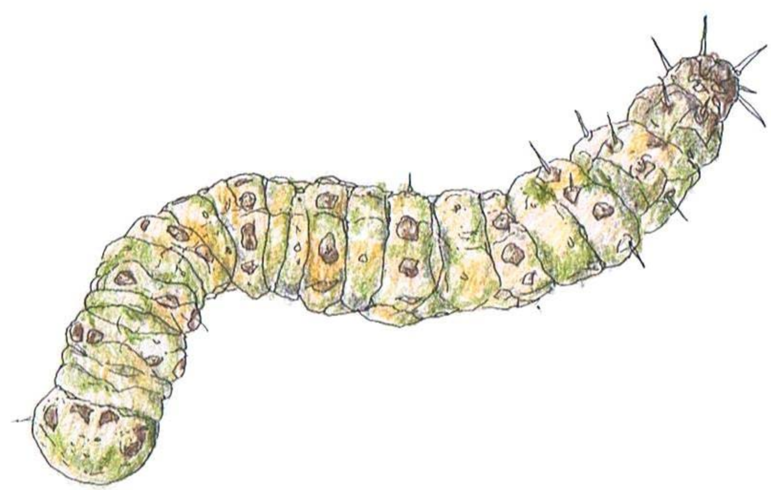
4. **Change in the definition of a licensed health care professional.**
   A licensed health care professional is defined as a physician, nurse, emergency medical technician, or other qualified individual, licensed or certified by a State to provide medical treatment.

5. **Change in accessing records to facilitate medical treatment.**
When the attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, determines that any record of the application of any restricted use pesticide required to be maintained is necessary to provide medical treatment or first aid to an individual who may have been exposed to the restricted use pesticide for which the record is or will be maintained, the certified applicator required to maintain the record shall promptly provide the record information and any available label information. If it is determined by the attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, to be a medical emergency, the record information of the restricted use pesticide, relating to the medical emergency, shall be provided immediately.

6. **Change in provisions for the release of record information obtained for purposes of medical treatment.**
(1) The attending licensed health care professional, or an individual acting under the direction of the attending licensed health care professional, may utilize and release the record or record information when necessary to provide medical treatment or first aid to an individual who may have been exposed to the ' restricted use pesticide for which the record is or will be maintained;
(2) the attending licensed health care professional may release the record or record information to appropriate Federal or State agencies that deal with pesticide use or any health issue related to the use of pesticides when necessary to prevent further injury or illness; and
(3) a licensed health care professional may release the record or record information to submit pesticide poisoning incident reports to the appropriate State or Federal agencies.

7. **Clarification that the Administrator of AMS, has flexibility in assessing civil penalties.**

The amended regulations provide the Administrator of AMS, or the Administrator's designee, with flexibility in assessing civil penalties.



EUROPEAN CORN BORER

When pesticides are released into the environment, they are either: 1) broken down, or degraded, by the action of sunlight, water or other chemicals, or microorganisms, such as bacteria; or 2) resist degradation and thus remain unchanged in the environment for long periods of time. The persistence of a pesticide is its ability to remain unchanged. Persistence is measured by half-life. The half-life is the time it takes for half of the initial amount of a pesticide to break down. Thus, if a pesticide's half-life is 30 days, half will be left after 30 days, one-quarter after 60 days, and one-eighth after 90 days and so on.

When the pesticide is broken down, this usually leads to the formation of less harmful products. However, in some instances the products can be more toxic than the original pesticide. Pesticides that are easily broken down generally move the shortest distance and have the least adverse effects on people or other organisms. Persistent pesticides generally move the longest distances and have the greatest potential to accumulate in living organisms.

Definition Section

The definitions and explanations presented here are limited to key terms to show the standard's range of coverage. Readers seeking more detailed information should contact their State agency that regulates pesticides or their regional EPA office and consult Title 40 Code of Federal Regulations, Part 170, and Title 7 United States Code.

Agricultural establishment means any farm, forest, nursery, or greenhouse (40 CFR).

Agricultural employer means any person who hires or contracts for the services of workers, for any type of compensation, to perform activities related to the production of agricultural plants, or any person who is an owner of or is responsible for the management or condition of an agricultural establishment that uses such workers (40 CFR).

Agricultural emergency means a sudden occurrence or set of circumstances that the agricultural employer could not have anticipated and over which the agricultural employer has no control, requiring entry into a treated area when no alternative practices would prevent or mitigate a substantial economic loss (a loss in profitability greater than that which is expected based on the experience and fluctuations of crop yields in previous years).

The State, tribal, or Federal agency having jurisdiction must declare the existence of circumstances that could cause an agricultural emergency on that agricultural establishment (40 CFR).

Agricultural plant means any plant grown or maintained for commercial, research, or other purposes. Included in this definition are food, feed and fiber plants, trees, turf grass, flowers, shrubs, ornamentals, and seedlings (40 CFR).

Farm means any operation, other than a nursery or forest, engaged in the outdoor production of agricultural plants (40 CFR, Section 170.3).

Forest means any operation engaged in the outdoor production of any agricultural plant to produce wood fiber or timber products (40 CFR).

Greenhouse means any operation engaged in the production of agricultural plants inside any structure or space that is enclosed with a nonporous covering and is of sufficient size to permit worker entry.

Polyhouses, mushroom houses, rhubarb houses, and similar structures are included, but not malls, atriums, conservatories, arboretums, or office buildings where agricultural plants are present primarily for aesthetic or climatic modification (40 CFR).

Hand labor means any agricultural activity performed by hand or with hand tools that causes a worker to have substantial contact with surfaces that may contain pesticide residues. Most hand labor activities, other than operating, moving or repairing irrigation or watering equipment, or scouting, are included (40 CFR).

Handler means any person employed for any type of compensation who: (1) mixes, loads, transfers, applies, disposes of, or transports open containers of pesticides; (2) acts as a flagger; (3) cleans, adjusts, or repairs the parts of mixing, loading, or application equipment that may contain pesticide residues; (4) must enter an area being treated with pesticides to assist in the application of pesticides; (5) must enter a greenhouse or other enclosed area after the application of a fumigant, smoke, mist, fog, or aerosol product to operate ventilation equipment or to monitor air levels before the exposure level listed in the labeling or one of the ventilation criteria has been met; (6) must enter a treated area to move chemigation equipment (used to apply pesticides with irrigation water) before a REI has expired; or (7) must enter a treated area outdoors after application of any soil fumigant to adjust or remove soil covers such as tarpaulins (40 CFR).

Immediate family includes only spouse, children, stepchildren, foster children, parents, stepparents, foster parents, brothers, and sisters (40 CFR).

Nursery means any operation engaged in the outdoor production of any agricultural plant to produce cut flowers and ferns or plants that will be used in their entirety in another location. Such plants include, but are not limited to: flowering and foliage plants or trees; tree seedlings; live Christmas trees; vegetable, fruit, and ornamental transplants; and turf grass produced for sod (40 CFR).

Owner means any person who has a present possessory interest (fee, leasehold, rental, or other) in an agricultural establishment covered by this part, unless that person has both leased such agricultural establishment to another person and granted that same person the right and full authority to manage and govern the use of such agricultural establishment (40 CFR).

Pesticide means "*any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant*..." (EPA, 1988).

Restricted entry interval means the time after the end of a pesticide application during which entry into the treated area is restricted (40 CFR).

Treated area means any area to which a pesticide is being directed or has been directed (40 CFR).

Worker means any person, including a self-employed person, who is employed for any type of compensation to perform activities relating to the production of agricultural plants on a farm or in a greenhouse, nursery, or forest.

These activities include hand labor tasks (weeding, planting, cultivating, and harvesting) and other tasks in the production of agricultural plants (such as operating or moving irrigation equipment).

While workers are performing pesticide handling activities, they are considered to be handlers subject to the requirements for handlers in the WPS.

Adjuvants

Activity of Adjuvants

Adjuvants, or additive compounds, aid in the mixing, application or effectiveness of pesticides. One class of adjuvants, **compatibility agents**, allow uniform mixing of compounds that would normally separate. Other types of adjuvants include **spreaders**, **stickers**, and **synergists**. There are nearly as many adjuvants as there are pesticides, and they provide a choice for every need. Some adjuvants are added during pesticide manufacture and are, thus, part of the formulation. Other adjuvants are added just before application. To decide when to use an adjuvant, ***READ THE LABEL*.** It will state when a particular adjuvant is needed, whether or not one should be added or when one is already present.

Adjuvants assist application or pesticide activity without being directly toxic to pests. However, many of these chemicals can present hazards to the applicators. The EPA has not required manufacturers to perform the same type of research and reporting on adjuvants that is required for pesticide registration. However, regulations are continually updated to protect the health of applicators and review and registration of adjuvants may be required in the future. Meanwhile, it is a good practice to use the same care in handling adjuvants as is used with pesticides.

Many, but not all, adjuvants function as **surfactants**, or surface active agents. Surfactants improve the retention and absorption of herbicides. The benefit that they provide is offset, to a degree, by the increased drift hazard they cause. Reducing the surface tension of the spray solution permits it to break up into finer droplets, which are more likely to drift off target.

Drift control agents are adjuvants that help reduce the risk of drift. Pesticide drift is off-target spray deposit and off-target damage.

Spray thickeners reduce drift by increasing droplet size and by reducing bounce or runoff during application. Use of these adjuvants helps to comply with drift regulations, which is especially important in areas adjacent to residential areas. Lo-Drift, Nalco-Trol and Drift Proof are examples of drift control agents.

Penetrating agents dissolve the waxy layer that protects the surface of leaves. This speeds up absorption with foliar treatments. Lower application rates used with these adjuvants may provide the same control as higher rates made without them; more chemical enters the plant before breaking down or washing off. Examples of penetrating agents include Arborchem and kerosene.

Proper Handling of Pesticides

Using pesticides involves many responsibilities beyond the immediate needs of pest control. Greenhouse growers, like all agricultural producers, are expected to handle hazardous materials in a manner that reduces the exposure risk to other persons and limits contamination of the environment.

Numerous federal and state regulations exist to help growers handle, store and apply pesticides properly.

In addition to FIFRA, the EPA has further authority over pesticide use under the Superfund Amendment and Reauthorization Act (**SARA**) and the Resource Conservation and Recovery Act (**RCRA**). These federal regulations cover all materials classified as hazardous and, therefore, apply to pesticides. Pesticide handling and storage are also regulated by the Transportation Safety Act and the Occupational Safety and Health Act (**OSHA**).

Moving Pesticides
Interstate transport of pesticides is regulated by the Federal Department of Transportation (**DOT**). Their guidelines for safe movement are common sense rules for any transport of chemicals. All pesticides should be in the original DOT approved containers and correctly labeled. All containers should be secured against movement that could result in breaking or spilling. Never transport pesticides in a vehicle that also carries food or feed products.

Never transport pesticides in the cab of vehicles. Paper or cardboard containers should be protected from moisture. Never leave an open-bed truck containing pesticides unattended. Following these procedures is necessary when moving concentrated chemicals and is good practice for diluted mixtures.

Persons transporting chemicals must have proper protective clothing available for the safe handling of the containers. The protective gear should be in or on the vehicle for immediate access in case a spill occurs. Protection of the person managing or cleaning up a spill is the primary concern.

Spill Cleanup and Reporting
What to do when a spill occurs
When a minor spill occurs, make sure the proper protective equipment is available, and wear it. If pesticide has spilled on anyone, wash it off immediately, before taking any other action. Confine the spill with a dike of sand or soil. Use absorbent materials to soak up the spill. Shovel all contaminated material into a leak- proof container and dispose of it in the same manner as excess pesticides. Do not hose down the area; this spreads the chemical. Always work carefully to avoid making mistakes.

Streams and wetlands must be protected in the event of an accidental spill of any size. Even diluted chemicals pose a threat to natural habitats when released in large amounts. Extra precautions must be taken when drawing water from streams or ponds. Antisiphoning devices must be used and be in good working order. Tank mixes should be prepared at least ¼ mile from water resources. If this is not possible, make sure the ground at the mixing site does not slope toward the water, or construct an earthen dike to prevent pesticides from flowing into bodies of water or drains.

Major spills of concentrates or large quantities of spray solution are difficult to handle without assistance. Provide any first aid that is needed and confine the spill, then notify the proper authorities. Contact the local fire department using the 911 system, if available. Other phone numbers for fire departments, state and local authorities should be carried in the vehicles and by the applicators.

Regardless of the size of the spill, keep people away from the chemicals. Rope off the area and flag it to warn others. Do not leave the site unless responsible help, such as emergency or enforcement personnel, is there to warn others.

Significant pesticide spills must be reported to your state pesticide lead agency. Applicators, or their employers, are responsible for telephoning a spray incident report to the State Agency as soon as practical after emergency health care and efforts to contain the spill have started.

The state agencies decide if it is necessary to call **CHEMTREC** (Chemical Transportation Emergency Center), a public service of the Manufacturing Chemicals Association located in Washington, DC CHEMTREC provides immediate advice for those at the scene of an emergency. This service is available 24 hours a day (1-800-424-9300) for emergencies only.

Decontamination

(1) Decontamination solutions can be used for decontaminating surfaces and materials where spills of dust, granular, wettable powders, or liquid pesticides have occurred. The bulk of the spilled pesticide should be cleaned up or removed prior to applying any decontaminant.

(2) Several materials may be used to decontaminate pesticides. Due to the many different pesticides available and the necessity to use the correct decontamination material, all decontamination activities must be carried out only after appropriate decontamination methods have been determined by the Environmental Coordinator and/or Spill Response Team. Many pesticides, especially the organophosphates, decompose when treated with lye
or lime. Fewer pesticides are decomposed by bleach. Other pesticides cannot be effectively decontaminated and should only be treated with detergent and water to assist in removal. The following table is a guide for decontaminating certain pesticides:

Use Lye or Lime for:	Use Chlorine Bleach for:	Do not use any decontamination Chemicals for these Pesticides:
acephate	calcium cyanide	alachlor
atrazine	chlorpyrifos	chloramben
captan	fonophos	chlorinated hydrocarbons
carbaryl		diuron
dalapon		methoxychlor
diazinon		pentachlorophenol
dichlorvos		picloram
dimethoate		2,4-D
malathion		bromacil
naled		glyphosate
propoxur		simazine

WARNING: There is a slight potential for creating toxic by-products when using these procedures. In critical situations, samples of affected soil, sediment, water, etc. should be sent to a laboratory for analysis to determine if decontamination was successful.

Pesticides amenable to treatment using lye or lime may be decontaminated when mixed with an excess quantity of either of these materials. Lye or lime can be used in either the dry form or as a 10% solution in water. Caution: caustic soda (lye) can cause severe eye damage to personnel not properly protected. Protect against contact by wearing unventilated goggles, long-sleeved work clothes with coveralls, neoprene gloves, and a chemical-resistant apron. An approved respirator should also be worn. Do not use lye on aluminum surfaces.

Bleach
For pesticides that can be degraded by treatment with bleach, in general use one gallon of household bleach (which contains approximately 5% sodium hypochlorite) per pound or gallon of pesticide spilled. If bleaching powder is used, first mix it with water (one gallon of water per pound of bleach) and add a small amount of liquid detergent. For safety reasons, a preliminary test must be run using small amounts of bleach and the spilled pesticide. The reaction resulting from this test must be observed to make sure the reaction is not too vigorous. Do not store in close proximity to, or mix chlorine bleach with, amine-containing pesticides. Mingling of these materials can cause a violent reaction resulting in fire. Calcium
hypochlorite is not recommended as a decontaminating agent because of the fire hazard.

Spilled granular/bait materials need only to be swept up. When there is doubt concerning which decontaminant is appropriate, only water and detergent should be used. Nonporous surfaces should be washed with detergent and water. The decontamination solution determined to be correct should be thoroughly worked into the surface. The decontamination solution should then be soaked up using absorbent material. The spent absorbent material is then placed into a labeled leakproof container for disposal.

Porous materials such as wood may not be adequately decontaminated. If contamination is great enough to warrant, these materials should be replaced. Tools, vehicles, aircraft, equipment and any contaminated metal or other nonporous objects can be readily decontaminated using detergent and the appropriate decontamination solution.

Disposal
All contaminated materials that cannot be effectively decontaminated as described above must be placed in properly labeled, sealed, leakproof containers. Disposal of these containers shall be in accordance with instructions determined by the U.S. Environmental Protection Agency/State Pesticide Agency and the Spill Response Team.

APPENDIX B
SAMPLE FORMS, FACT SHEETS, AND CHECKLISTS

Appendix B includes a sample Pesticide Application Information form with space for the pesticide application information the WPS requires to be listed at a central location on each agricultural establishment. The WPS does not specify a format for presenting the information — you may copy this form or design another that meets your needs. Appendix B also includes several fact sheets to help you comply with sections of the WPS that require you to provide information to others. Although the WPS does not require you to provide this information in written form, you may find that using photocopies of these fact sheets is a convenient way to make sure you convey the necessary information.

Finally, Appendix B includes some checklists and charts you can use as reminders of your WPS duties.

AGRICULTURAL ESTABLISHMENT OWNERS AND OPERATORS:
The use of this form is optional, but if the information about an application is entered, it will help you comply with the federal Worker Protection Standard including all revisions through 2004 for information that must be displayed at a central place to inform workers and handlers about specific pesticide applications. For complete information, see the EPA manual "The Worker Protection Standard for Agricultural Pesticides: How To Comply."
Application #1 Application #2
Area Treated: Location & Description
Product Name
EPA Registration Number
Active Ingredient: Common or Chemical Name
Application: Month/Day/Time
Restricted-Entry Interval
Do Not Enter Until: Month/Day/Time

Similar data is required by the Federal Recordkeeping Requirements for Certified Applicators of Federally Restricted Use Pesticides (RUP). For more information on the RUP recordkeeping requirements, contact Agricultural Marketing Service, USDA, 8609 Sudley Road, Suite 203, Manassas, VA 20110, (703) 330-7826. Please consult the "USDA Recordkeeping Manual" at the following Web site for a complete list of all USDA record keeping requirements: http://www.ams.usda.gov/science/prb/Prbforms.htm

Some states, tribes, or local governments with jurisdiction over pesticide enforcement may have additional worker protection requirements beyond these requirements. Check with these agencies to obtain the information you need to comply with all applicable state, tribal, or local requirements.

Worker Protection: Check to See if You Are in Compliance

This checklist serves only as a brief overview of basic WPS requirements. For complete details of your responsibilities, refer to the "How to Comply Manual" or contact your nearest EPA office.

Central Location:
All information should be legible, up-to-date, and accessible to employees The EPA approved Safety Poster is posted and complete Display emergency medical information. The following records are displayed and available for at least 30 days following expiration of the restricted re-entry interval (REI): location of treated area, pesticide product name, active ingredient, EPA registration number, start date and time of the application, and REI.

Pesticide Safety Training: Complete WPS Training has been given to:
Workers prior to the 6th day of entering any treated areas and every 5 years thereafter Handlers prior to performing any handler tasks and every 5 years thereafter "Basic Pesticide Safety Information" is provided to workers as necessary EPA developed or equivalent training materials are used in training. Training is presented in a language the trainees can understand Trainers are properly qualified.

Decontamination Sites: Handler decontamination sites have/are:
At least 3 gallons of water per handler, soap, single-use towels, and coveralls Located at mixing/loading sites, within 1/4 mile of the application site and where PPE is removed Supplied with at least 1 pint of immediately available clean water for eye flushing when the label specifies the use of protective eyewear.

Worker decontamination sites have/are:
At least 1 gallon of water per handler, soap, and single-use towels Located within 1/4 mile of the work site. Provided for 30 days following the end of the REI (7 days with REIs of 4 hours or less).

Applicator Notification:
Oral and/or posted warnings given according to label requirements.
Appropriate warning signs are used and posted at all usual entry points to treated areas.
Warning signs are posted not more than 24 hours prior to treatment and removed within 3 days following the end of the REI.
Oral warnings are given in a language workers can understand.

Personal Protective Equipment (PPE):
Label required PPE is provided for handlers and early entry workers PPE is kept clean and well maintained. A clean place for PPE storage is provided.

Employer Information Exchange: Custom applicator supplies information for Central Location. Posting **prior** to applications Information is supplied to custom applicators about REIs in effect on the property which they are exposed to.

Monitoring Handlers:
Sight or voice contact made at least every 2 hours with handlers using Skull & Crossbones pesticides. Constant voice or visual contact is maintained with handlers using fumigants indoors.

INFORMATION ABOUT CLEANING PPE
PROTECT YOURSELF FROM PESTICIDES

1. The clothing and protective equipment items you will be cleaning may have pesticides on them.

2. Although you may not be able to see or smell the pesticides, they can rub off on you when you touch the clothing and equipment.

3. If pesticides get on you, they can hurt you. They can:
• cause skin rashes or burns,
• go through your skin and into your body and make you ill,
• burn your eyes,
• make you ill if you breathe them or get them in your mouth.

4. To avoid harm from the pesticide, you should:
• Pour the clothes from their container into the washer without touching them.
• Handle only the inner surfaces, such as the inside of boots, aprons, or coveralls.
• Do not breathe the steam from the washer and dryer.

5. Pesticides should not be allowed to stay on your hands:
• When you wash clothing or equipment by hand, use plenty of water and rinse your hands often.
• Wash your hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
• Wash your hands as soon as you finish handling the clothing or equipment.

6. You should not allow clothing and equipment with pesticides on them to be washed with regular laundry. The pesticides can rub off on other items.

Cleaning Eyewear and Respirators
Hand-wash reusable respirator facepieces, goggles, face shields, and shielded safety glasses, following manufacturer's instructions. In general, use mild detergent and warm water to wash the items thoroughly. Rinse well. Wipe dry, or hang in a clean area to air dry.

Cleaning Other PPE
1. Follow the manufacturer's cleaning instructions. If the instructions say only to wash the item, or if there are no cleaning instructions, follow the procedure below.

2. Recommended procedure for washing most PPE:
a. **Rinse** in a washing machine or by hand.
b. **Wash in a washing machine**, using a heavy-duty detergent and hot water for the wash cycle.
c. **Wash only a few items at a time** to allow plenty of agitation and water for dilution. Use the highest water-level setting.
d. **Rinse twice** using two rinse cycles and warm water.
e. **Use two entire machine cycles** to wash items that are moderately to heavily contaminated.
f. **Run the washer through at least one more entire cycle** without clothing, using detergent and hot water, to clean the machine.

3. Some plastic or rubber items that are not flat, such as gloves, footwear, and coveralls, must be washed twice — once to clean the outside and a second time after turning the item inside out.

4. Some items, such as heavy-duty boots and rigid hats or helmets, should be washed by hand using hot water and heavy-duty detergent.

5. **Hang the items to dry**, if possible. Let them hang for at least 24 hours in an area with plenty of fresh air — preferably outdoors. Do not hang items in enclosed living areas.

6. You may **use a clothes dryer** for fabric items if it is not possible to hang them to dry. But after repeated use, the dryer may become contaminated with pesticides.

Note to Employers:
This fact sheet will help you comply with the section of the WPS that requires you to provide information to people (other than your own handlers) who clean or maintain you pesticide equipment. You are not required to give them this information in written form, but you may find that photocopying this fact sheet is an easy way to pass along the necessary information.

WORKING SAFELY WITH PESTICIDE EQUIPMENT

1. The equipment you will be cleaning, adjusting, or repairing may have pesticides on it. Although you may not be able to see or smell the pesticides, they can rub off on you when you touch the equipment.

2. If pesticides get on you, they can hurt you. They can:
• cause skin rashes or burns,
• go through your skin and into your body and make you ill,
• burn your eyes,
• make you ill if you get them in your mouth.

3. You should wear work clothing that protects your body from pesticide residues, such as long-sleeved shirts, long pants, shoes, and socks. If possible, avoid touching the parts of the equipment where the pesticide is most likely to be. Or, if practical for the job that you will be doing, consider wearing rubber or plastic gloves and an apron.

4. You should not let pesticides stay on your hands:
• Wash your hands as soon as you finish handling the equipment.
• Wash your hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
• Wash or shower with soap and water, shampoo your hair, and put on clean clothes after work.
• Wash work clothes that may have pesticides on them separately from other clothes before wearing them again.

Personal Protective Equipment Section

Pesticides are necessary for agricultural production but potential hazards to users are not adequately emphasized. Accidents involving pesticides are usually due to improper handling, mixing, application of pesticides, or failure to use proper personal protective equipment and clothing.

General Guidelines
The minimum protection when working with pesticides is long sleeves, long pants, shoes and socks, rubber gloves, and splash-proof eye protection, regardless of the toxicity level of the pesticide. Rubber boots and a respirator are necessary when working with moderately or highly toxic pesticides. The EPA's recommendations include wearing a double layer of clothing. This can be accomplished by wearing coveralls over the long pants and longsleeve shirt, and rubber boots over the shoes and socks.

Gloves
The use of gloves is mandatory when working with highly toxic pesticides. It is recommended that only unlined rubber or neoprene (nitrile, etc.) gloves be used when handling or using all pesticides. Unlined gloves should be thoroughly washed (inside and outside) after each use.

Gloves should be at least 12 inches long to provide adequate protection for wrists and the cuffs should be inside sleeves for most work. This will keep runoff pesticide from getting into the gloves. However when working overhead put the cuffs of gloves outside sleeves.

Check rubber type gloves for leaks each time they are washed. Do this by filling gloves with water and fold the cuff over to put pressure on the water in the glove.

If there are holes water will leak out. Discard gloves with leaks. **NEVER USE CLOTH OR LEATHER GLOVES WHEN WORKING WITH PESTICIDES** unless specified on the label.

Goggles and Face Shields
It is necessary to wear splash-proof goggles when working with pesticides. Not only can the pesticide be absorbed through the eyes but the acidity of a pesticide can cause permanent eye injuries also. Use goggles meeting or exceeding ANSI standard Z87.1, 1968 estimate. When pouring or mixing concentrates it is preferable to use a full-face shield to protect the face from splashes. Always wash the goggles or face shield with soap and water after use.

Boots
Unlined rubber or neoprene (nitrile, etc.) boots should be worn over work shoes or in place of work shoes when mixing or applying pesticides. Pull the legs of trousers over the tops of boots to help prevent spilled pesticide from getting inside boots. Wash boots with soap and water after each use.

NEVER WEAR CLOTH OR LEATHER BOOTS WHEN MIXING, OR APPLYING PESTICIDES. Cloth or leather boots will absorb pesticides and allow the pesticide to contact the skin of the leg or foot and will be a source of residues causing chronic exposure.

Headwear
A waterproof hat should be worn when mixing or applying pesticides because pesticides can be readily absorbed through the scalp. The hat should have a brim to keep drift or splashes off ears and neck. Plastic safety hats are ideal for use with pesticides and should be washed in soap and water after each use. Cloth hats may absorb pesticides and contaminate the wearer. **DO NOT USE CLOTH HATS.**

Respirators
Respirators are designed to prevent inhaling toxic fumes and mists. They should be used when mixing or applying pesticides if the label specifies the need. Choose the correct cartridge for the type of pesticide being used. The manufacturer or supplier can provide guidance on selecting correct cartridges.

Replace cartridges when the odor of the pesticide becomes noticeable or when breathing becomes difficult during use. The life of cartridges will vary with the concentration of pesticide in the air around the respirator breathing rate of the user temperature humidity and composition of the cartridge. Respirators **SHOULD NOT** be used in low oxygen atmospheres (below 19.5 percent oxygen). Respirators **WILL NOT** provide adequate protection for a person having a beard. Choose the model and make of respirator that provides a good seal between the face piece and the face to prevent pesticides from leaking into the respirator and being breathed.

Always wash the face piece and straps in soap and water after each use. After drying place the respirator and cartridges in a clean plastic bag until they are needed again. Select respirators having the approval of NIOSH or MESA.

Personal Protective Equipment Policy Example

Scope
This section applies to all pesticide workers and handlers.

Purpose
To assure employees are protected from chemical, physical and biological hazards by the use of personal protective equipment (**PPE**). PPE is designed and selected to protect the body from absorption, inhalation, physical contact and extreme temperature hazards.

Personal protective equipment includes, but is not limited to safety glasses, goggles, face shields, hard hats, gloves, safety-toe boots, respirators and earplugs/muffs.

Supervisor's Responsibilities
Supervisors assess workplaces to identify hazards that their employees are potentially exposed to during the course of their work. Hazard assessments are performed by observing work practices, interviewing employees and reviewing chemical material safety data sheets and tool/equipment manufacturer's instructions.

Supervisors select PPE based on the types of hazards identified during the assessments, level of protection needed, fit and comfort.

Supervisors are to ensure employees are provided with, and wear, PPE.

Hazard assessments are to be conducted whenever new equipment, processes or chemicals are introduced or an injury or illness indicates the need for PPE.

NOTE: Safety Officer or Supervisor conducts noise and respiratory protection hazard assessments.

Training
Supervisors ensure employees are trained in the proper use of PPE. Employees are to receive information and training about why and when PPE is needed; how to put on, remove and adjust PPE; the use and limits of PPE, and how to care for and inspect PPE.

NOTE: Safety Officer or Supervisor conducts noise and respiratory protection training.

Recordkeeping Requirements

Supervisors document that hazard assessments have been conducted using copies of the certification form found following this section.

Supervisors document training using copies of the certification form following this section.

NOTE: Safety Officer or Supervisor documents noise and respiratory protection hazard assessments and training.

<table>
<tr><th colspan="3">Personal Protective Equipment Training Certification</th></tr>
<tr><td>_______________________
Employee's name</td><td colspan="2">has been assigned and trained to use the following personal protective equipment when working in areas and/or tasks identified below:</td></tr>
<tr><td>Area/Task</td><td>PPE Required _ X Applicable Lines</td><td>PPE Selected (Make and Model)</td></tr>
<tr><td></td><td>__ Eye/Face Protection
__ Head Protection
__ Hand Protection
__ Hearing Protection
__ Respiratory Protection
__ Other:_________________</td><td></td></tr>
<tr><td>Area/Task</td><td>PPE Required _ X Applicable Lines</td><td>PPE Selected (Make and Model)</td></tr>
<tr><td></td><td>__ Eye/Face Protection
__ Head Protection
__ Hand Protection
__ Hearing Protection
__ Respiratory Protection
__ Other:_________________</td><td></td></tr>
<tr><td>I,
_________________________,</td><td colspan="2">have received and understood the training on the PPE listed above. This training included the areas, tasks and hazards requiring PPE; how to properly put on, wear, and take off the PPE; PPE selection criteria, and the proper care, inspection, maintenance, useful life and disposal of the PPE.</td></tr>
<tr><td colspan="2">Supervisor:</td><td>Date(s) of Training:</td></tr>
</table>

Respiratory Protection Section

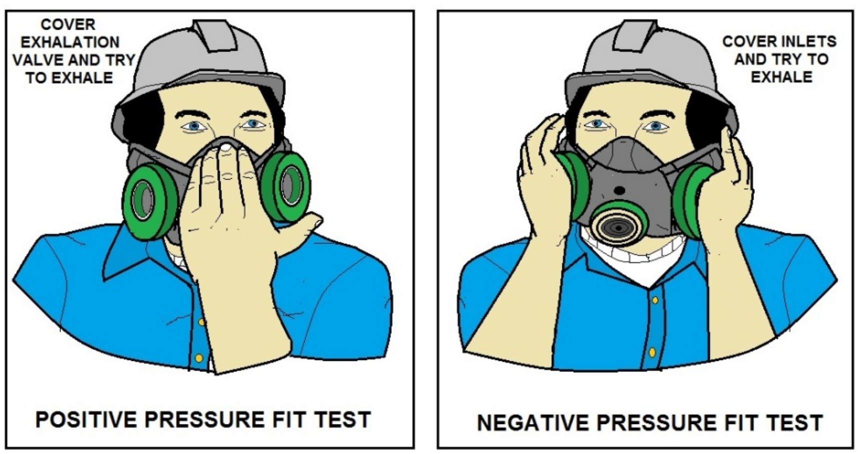
General
In the Respiratory Protection program, hazard assessment and selection of proper respiratory PPE is conducted in the same manner as for other types of PPE. In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination.

This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used.

References: OSHA Standards ***Respiratory Protection*** (29 CFR 1910.134)

Why Respirators Are Needed
Respirators protect against the inhalation of dangerous substances (vapors, fumes, dust, gases). They can also provide a separate air supply in a very hazardous situation.

Some of the health hazards that respirators prevent include:
- *Lung damage*
- *Respiratory diseases*
- *Cancer and other illnesses.*



POSITIVE AND NEGATIVE PRESSURE FIT CHECKS

Respiratory Protection Responsibilities:
The employer is responsible for,
- Providing training in the use and care of respirators
- Ensuring that equipment is adequate, sanitary, and reliable
- Allowing employees to leave area if ill, for breaks, and to obtain parts
- Fit testing
- Providing annual medical evaluation
- Providing a powered air-purifying respirator (**PAPR**) if an employee cannot wear a tight-fitting respirator

The employee is responsible for:
- Properly using respirators
- Maintaining respirator properly
- Reporting malfunctions
- Reporting medical changes

Selection of Respiratory Protection
When choosing the correct respiratory protection for your work environment, it is important to consider:

- Identification of the substance or substances for which respiratory protection is necessary

- A substance's safety data sheet (**SDS**) (it will state which type of respirator is most effective for the substance)

- Activities of the workers

- Hazards of each substance and its properties

- Maximum levels of air contamination expected

- Probability of oxygen deficiency

- Period of time workers will need to use the respiratory protection devices

- Capabilities and physical limitations of the device used

Basic Types of Respirators
Air-purifying or filtering respirators. Such respirators are used when there is enough oxygen (at least 19.5 percent) and contaminants are present below IDLH level. The respirator filters out or chemically "***scrubs***" contaminants, usually with a replaceable filter. Use color-coded filter cartridges or canisters for different types of contaminants. It's important to select the right filter for the situation.

Air-supplying respirators. These respirators are required when air-purifying respirators aren't effective.

Air-purifying respirators are not sufficient in the following settings:
- When there is not enough oxygen
- Confined spaces
- When contaminants cannot be filtered out
- When contaminants are at or above IDLH level.

Different kinds of Air-Supplying Respirators include

- Those connected by hose to stationary air supply (air line)
- Portable tank self-contained breathing apparatus (**SCBA**).

The Importance of Correct Fit

Even a tiny gap between the respirator and the face can allow contaminants to enter. Respirators should be comfortable and properly fitted. Proper fit includes:

- Secure but not too tight
- No slipping or pinching
- Allowance for head movement and speech

An OSHA-accepted qualitative fit test or quantitative fit test must be performed prior to an employee using any tight-fitting respirator.

Tight-fitting respirators must be seal checked before each use by using positive- or negative-pressure check procedures or the manufacturer's instructions.

Respirator Filters/Cartridges

For protection against gases and vapors, the cartridges used for air-purifying respirators must be either equipped with an end-of-service-life indicator (**ESLI**), certified by NIOSH for the contaminant, or a cartridge change schedule has to be established.

For protection against particulates, there are nine classes of filters (three levels of filter efficiency, each with three categories of resistance to filter efficiency degradation). Levels of filter efficiency are 95 percent, 99 percent, and 99.97 percent. Categories of resistance to filter efficiency degradation are labeled N, R, and P.

Protection Factors

The protection factor of a respirator is an expression of performance based on the ratio of two concentrations: The contaminant concentration outside the respirator to the contaminant concentration inside the respirator.

Each class of respirator is also given an assigned protection factor (**APF**). The APF is a measure of the minimum anticipated level of respiratory protection that a properly functioning respirator or class of respirators would provide to a percentage of properly fitted and trained users.

When a contaminant concentration is known, the APF can be used to estimate the concentration inside a particular type of respirator worn by a user.

Who Cannot Wear a Respirator?

Respirator fit is essential. Employees must have a medical checkup to make sure they can wear respirators safely. Generally, respirators cannot be worn when a person:

- Wears glasses or personal protective equipment that interferes with the seal of the face piece to the face of the user
- Has facial hair that comes between the sealing surface of the face piece and the face or interferes with valve function
- Has a breathing problem, such as asthma
- Has a heart condition
- Is heat sensitive

Sometimes a person's facial features will not permit a good fit. Check with the supervisor or medical department if the fit is a problem.

Checking for Damage
Before each use, make sure there are no holes, tears, etc., in the respirator. Rubber parts can wear out and should be checked very carefully every time a respirator is used. Replace worn and damaged parts when necessary. Make sure air and oxygen cylinders are fully charged.

Staying Prepared for Respirator Use
Respirators are bulky and awkward, so getting used to them takes practice. Possible problems with wearing respirators may include heat exhaustion or heat stroke. Be alert for symptoms, use the "buddy system," and wear a lifeline or harness when necessary. Drink plenty of fluids and take frequent breaks.

Poor maneuverability. Practice with respirators in narrow passages, on ladders, etc., if your use of respirators may be in these types of conditions.

Using up the air supply. When a SCBA is in use, keep checking the gauges and listening for alarms; be ready to leave the area immediately if there is a problem.

Panic. Remember the importance of staying calm in a hot, stressful, or awkward situation.

Cleaning Respirators
Respirators should be cleaned and disinfected after every use. Check the respirator for damage before putting it away; look for holes, cracks, deterioration, dented cartridges, etc. If any damage is found, it should be reported to a supervisor. Respirators stored for emergency use must be inspected monthly when not in use, as well as after each use.

Respirators should be stored away from light, heat, cold, chemicals, and dust. Store respirators in a "***normal***" (natural, undistorted) position to hold their shape. Do not allow respirators to get crushed, folded, or twisted.

Overview

OSHA requires that supervisors consult with employees and encourage their participation in the process safety management plan. In fact, managers must have a written plan of action for employee participation in process safety management. Employee participation is critical because;

- Employees know a lot about the process they work on.
- They play key roles in making sure that process operation is conducted safely.

Operating Procedures
Managers must furnish written operating procedures that clearly explain how to perform each covered process safely. The procedures must be accurate and must be written in language that employees can understand. Avoid technical jargon and, if necessary, supply translations.

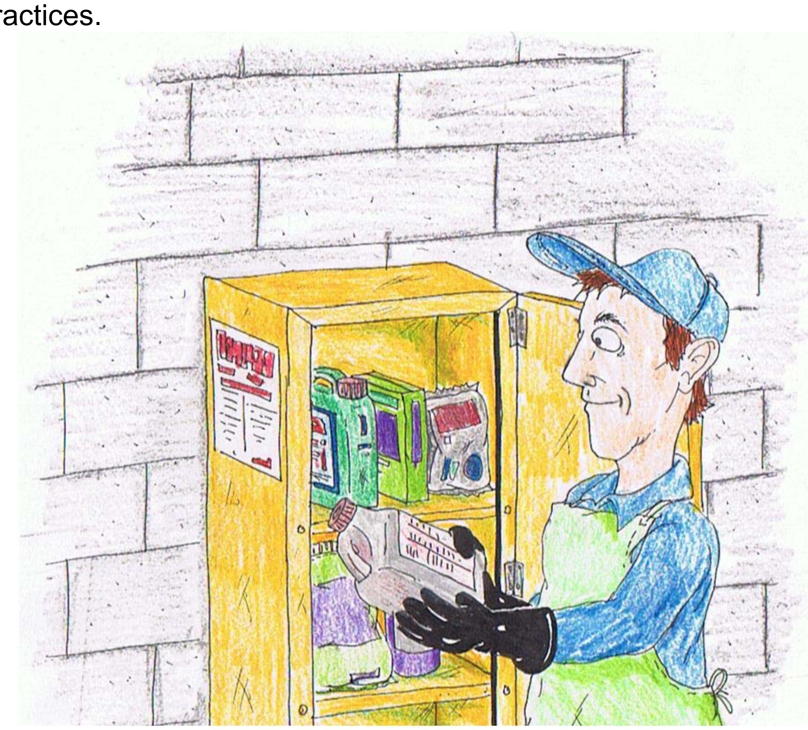
Operating procedures must include at least the following:

- Operating steps for initial startup, normal and temporary operations, emergency shutdown (including when it's called for and who does it), emergency operations, normal shutdown, and startup after a turnaround or an emergency shutdown.

- Operating limits, including what happens if workers don't conform to operating limits and how to avoid or correct such problems.

- Safety and health considerations, such as chemical or other hazards, precautions to prevent exposure, quality and inventory control for chemicals, and what to do if an employee is exposed to a hazardous substance.

- Safety systems and their functions, including up-to-date operating procedures and safe work practices.



Contractor Employees

Process safety training and safety programs are also required for contractors who work on-site. Managers must check out the safety performance and programs of any contractors being considered for maintenance, repair, turnaround, major renovation, or specialty work on or around a process covered by the regulation.

When a contractor is hired, the manager must provide the contractor with information on the hazards of the process the contractor will work on. To further ensure contractor safety, managers must also:

- Provide the contractor with information on safe work practices for the process they're involved with and tell them what to do in an emergency.
- Keep a log of contractor employees' injuries or illnesses related to their work in process areas.
- Evaluate the contractor's performance to make sure they're living up to their safety obligations under the standard.

The contractor has responsibilities, too.

- Document that employees are trained to recognize hazards and to follow safe work practices on the job.
- Make sure that the contractor's employees understand potential job-related hazards, are trained to work safely, and follow the safety rules of the facility in which they're working.

Respiratory Protection Program

This paragraph requires the employer to develop and implement a written respiratory protection program with required worksite-specific procedures and elements for required respirator use. The program must be administered by a suitably trained program administrator. In addition, certain program elements may be required for voluntary use to prevent potential hazards associated with the use of the respirator.

The Small Entity Compliance Guide contains criteria for the selection of a program administrator and a sample program that meets the requirements of this paragraph. Copies of the Small Entity Compliance Guide is available from the Occupational Safety and Health Administration's Office of Publications, Room N 3101, 200 Constitution Avenue, NW, Washington, DC, 20210 (202-219-4667).

(c)(1) In any workplace where respirators are necessary to protect the health of the employee or whenever respirators are required by the employer, the employer shall establish and implement a written respiratory protection program with worksite-specific procedures. The program shall be updated as necessary to reflect those changes in workplace conditions that affect respirator use. The employer shall include in the program the following provisions of this section, as applicable:

(c)(1)(i) Procedures for selecting respirators for use in the workplace;

(c)(1)(ii) Medical evaluations of employees required to use respirators;

(c)(1)(iii) Fit testing procedures for tight-fitting respirators;

(c)(1)(iv) Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations;

(c)(1)(v) Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators;

(c)(1)(vi) Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators;

(c)(1)(vii) Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations;

Example of Responsibilities

All Employees shall follow the requirements of the Respiratory Protection Program.

Management
- implement the requirements of this program
- provide a selection of respirators as required
- enforce all provisions of this program
- appoint a *Specific Designated* individual to conduct the respiratory protection program

Administrative Department
- Review sanitation/storage procedures.
- ensure respirators are properly, stored, inspected and maintained.
- monitor compliance for this program.
- provide training for affected Employees.
- review compliance and ensure monthly inspection of all respirators.
- provide respirator fit testing.

Designated Occupational Health Care Provider
- conducts medical aspects of program.

Program Administrator
Each Department will designate a program administrator who is qualified by appropriate training or experience that is commensurate with the complexity of the program to administer or oversee the respiratory protection program and conduct the required evaluations of program effectiveness.

Voluntary Use of Respirators is Prohibited
OSHA requires that voluntary use of respirators, when not required by the Employer, must be controlled as strictly as under required circumstances. To prevent violations of the Respiratory Protection Standard, Employees are not allowed voluntary use of their own or Employer supplied respirators of any type.

Exception: Employees whose only use of respirators involves the voluntary use of filtering (non-sealing) face pieces (dust masks).
See appendix D.

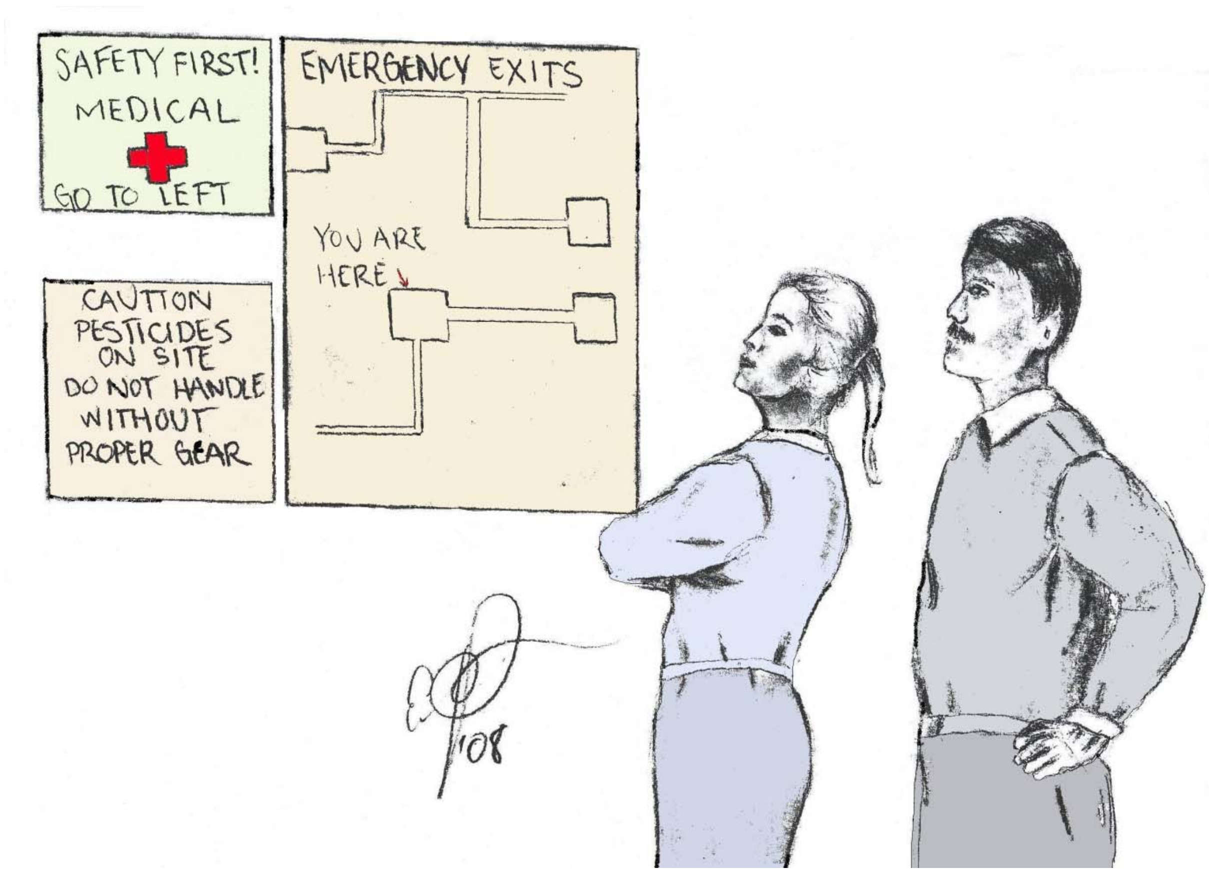

Program Evaluation

Evaluations of the workplace are necessary to ensure that the written respiratory protection program is being properly implemented; this includes consulting with employees to ensure that they are using the respirators properly. Evaluations shall be conducted as necessary to ensure that the provisions of the current written program are being effectively implemented and that it continues to be effective.

Program evaluation will include discussions with employees required to use respirators to assess the employees' views on program effectiveness and to identify any problems.

Any problems that are identified during this assessment shall be corrected. Factors to be assessed include, but are not limited to:

- Respirator fit (including the ability to use the respirator without interfering with effective workplace performance);
- Appropriate respirator selection for the hazards to which the employee is exposed;
- Proper respirator use under the workplace conditions the employee encounters; and
- Proper respirator maintenance.



Recordkeeping
The Employer will retain written information regarding medical evaluations, fit testing, and the respirator program.

This information will facilitate employee involvement in the respirator program, assist the Employer in auditing the adequacy of the program, and provide a record for compliance determinations by OSHA.

Training and Information
Effective training for employees who are required to use respirators is essential. The training must be comprehensive, understandable, and recur annually and more often if necessary. Training will be provided prior to requiring the employee to use a respirator in the workplace.

The training shall ensure that each employee can demonstrate knowledge of at least the following:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator
- Limitations and capabilities of the respirator
- How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions
- How to inspect, put on and remove, use, and check the seals of the respirator
- What the procedures are for maintenance and storage of the respirator
- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators
- The general requirements of this program

Retraining shall be conducted annually and when:

- changes in the workplace or the type of respirator render previous training obsolete
- inadequacies in the employee's knowledge or use of the respirator indicate that the employee has not retained the requisite understanding or skill
- other situations arise in which retraining appears necessary to ensure safe respirator use

Training is divided into the following sections:

Classroom Instruction
1. Overview of the Employer’s Respiratory Protection Program & OSHA Standard
2. Respiratory Protection Safety Procedures
3. Respirator Selection
4. Respirator Operation and Use
5. Why the respirator is necessary
6. How improper fit, usage, or maintenance can compromise the protective effect.
7. Limitations and capabilities of the respirator.
8. How to use the respirator effectively in emergency situations, including respirator malfunctions
9. How to inspect, put on and remove, use, and check the seals of the respirator.
10. What the procedures are for maintenance and storage of the respirator.
11. How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators.
12. Change out schedule and procedure for air purifying respirators.

Fit Testing Hands-on Respirator Training (see appendix A for more information)
1. Respirator Inspection
2. Respirator cleaning and sanitizing
3. Record Keeping
4. Respirator Storage
5. Respirator Fit Check
6. Emergencies

Basic Respiratory Protection Safety Procedures

1. Only authorized and trained Employees may use Respirators. Those Employees may use only the Respirator that they have been trained on and properly fitted to use.
2. Only Physically Qualified Employees may be trained and authorized to use Respirators. A pre-authorization and annual certification by a qualified physician will be required and maintained. Any changes in an Employees health or physical characteristics will be reported to the Occupational Health Department and will be evaluated by a qualified physician.
3. Only the proper prescribed respirator or SCBA may be used for the job or work environment. Air cleansing respirators may be worn in work environments when oxygen levels are between 19.5 percent to 23.5 percent and when the appropriate air cleansing canister, as determined by the Manufacturer and approved by NIOSH or MESA, for the known hazardous substance is used. SCBAs will be worn in oxygen deficient and oxygen rich environments (below 19.5 percent or above 23.5 percent oxygen).
4. Employees working in environments where a sudden release of a hazardous substance is likely will wear an appropriate respirator for that hazardous substance (example: Employees working in an ammonia compressor room will have an ammonia APR respirator on their person.).
5. Only SCBAs will be used in oxygen deficient environments, environments with an unknown hazardous substance or unknown quantity of a known hazardous substance or any environment that is determined ***"Immediately Dangerous to Life or Health"*** (**IDLH**).
6. Employees with respirators loaned on "permanent check out" will be responsible for the sanitation, proper storage and security. Respirators damaged by normal wear will be repaired or replaced by the Employer when returned.
7. The last Employee using a respirator and/or SCBA that are available for general use will be responsible for proper storage and sanitation. Monthly and after each use, all respirators will be inspected with documentation to assure its availability for use.
8. All respirators will be located in a clean, convenient and sanitary location.
9. In the event that Employees must enter a confined space, work in environments with hazardous substances that would be dangerous to life or health should an RPE fail (a SCBA is required in this environment), and/or conduct a HAZMAT entry, a "***buddy system***" detail will be used with a Safety Watchman with constant voice, visual or signal line communication. Employees will follow the established Emergency Response Program and/or Confined Space Entry Program when applicable.
10. Management will establish and maintain surveillance of jobs and work place conditions and degree of Employee exposure or stress to maintain the proper procedures and to provide the necessary RPE.
11. Management will establish and maintain safe operation procedures for the safe use of RPE with strict enforcement and disciplinary action for failure to follow all general and specific safety rules. Standard Operation Procedures for General RPE use will be maintained as an attachment to the Respiratory Protection Program and Standard Operation Procedures for RPE use under emergency response situations will be maintained as an attachment to the Emergency Response Program.

Integrated Pest Management Section

IPM offers growers an array of tools to help manage pest problems. At the foundation of this approach are good growing practices, preventive pest management measures, and a regular pest monitoring program that enables producers to accurately determine if a pest control measure is economically justified. IPM uses a common sense approach to find the weak link in a pest's life cycle.

Sound pest programs do not attempt to eradicate pests, but rather to manage them so that economic crop losses are minimized. IPM is the primary BMP for pest management.

It involves combining practices such as:

- Selecting crops and varieties which are resistant to pest pressures.
- Timing planting and harvest dates to minimize pest damage.
- Rotating crops.
- Monitoring pest and natural enemy populations.
- Employing beneficial insects and other biological controls.

The philosophy behind the IPM approach is to create unfavorable conditions for pest buildup by enhancing crop vigor and by protecting natural enemies that aid in controlling pest populations.

IPM relies on a combination of practices to reduce damage by insects and related pests. Crop rotation and resistant varieties can be used to avoid some pest problems. Identifying pests promptly allows necessary and effective treatments to be applied before pest populations reach damaging levels. Treating a pest problem with either synthetic or natural pesticides is only a temporary solution. If a pest is recurring from year to year, then a new management strategy should be developed. As usually practiced, IPM includes judicious use of chemical pesticides applied only after scouting reveals pests at economically damaging threshold levels.

Scouting

An IPM program depends on good scouting. The scout walks through the field and inspects plants for insects at least once a week, sometimes more frequently when weather and season favor rapid pest buildups. Scouting for pests can prevent damage by identifying problems early, and it can save money if fewer treatments are needed (see Grower Example 1.)

Scouts target specific insects and select search techniques accordingly. Grasshoppers, for example, appear first on field edges, spider mites next to harvested small grains, and armyworms next to wheat. Other specific scouting tips are given later in this chapter. As well as looking carefully at a random sample of plants, scouts may use sweep nets to sample highly mobile insects such as potato leafhoppers.

Bean leaf beetles, cucumber beetles, Mexican bean beetles, and stinkbugs will drop onto a ground cloth or 'beat sheet' when the plant is shaken. Bright, adhesive-covered cards placed near plants will trap small, hard-to-see insects such as aphids, thrips, and whiteflies. Aphids and whiteflies are attracted to yellow cards and thrips to blue ones.

Grower Example 1
Replacing automatic spray schedules with as-needed treatments based on scouting reports saved 62 percent of a group of Florida vegetable growers an average of $95 per acre. The remaining 38 percent reported costs of monitoring equaled pesticide savings. Thus all growers did at least as well economically as if they had used scheduled pesticide applications and most did better.

For some pests, adult populations are monitored for advance warning of egg-laying and larval stages. This gives the grower time to detect population buildup before damage from the larvae occurs and to schedule any necessary treatments.

Black light traps are used to attract night-flying adults of such species as the European corn borer, corn earworm, armyworm, cabbage looper, hornworm, and some types of beetles. Adults of many moths, including most of those in the cabbageworm complex, can be lured to traps by manufactured sex signals (pheromones). The pheromones for each species are different and placement of the trap must be correct in terms of height, field location (edge or center) number of lures placed, and type of lure used. Manufacturers will provide these details, but some general guidelines are given below.

Economic Injury Thresholds
Economic injury thresholds are available for some, but not all, pests in the southern states. Economic injury levels given in this chapter are only intended as general guidelines. Information from cooperative extension agents and the experience of local growers are the best guides.

Insecticide Use
Before any insecticide is used in an IPM program, the presence of damaging levels of a pest insect should be confirmed by scouting. Unnecessary applications of insecticide increase costs, promote development of insecticide resistance, and degrade the environment. Use of insecticides sometimes increases the numbers of non-target pests.

On potatoes, for example, carbaryl (**Sevin**) application has produced peak green peach aphid populations that were more than ten times greater than those in untreated plots. The main factor in this population increase was direct stimulation of aphid reproduction by the carbaryl.

Total nitrogen content, which has been shown to increase aphid populations, also increased slightly, but predator and parasite populations were not affected by carbaryl.

Once the need for an insecticide is confirmed, it should be applied as efficiently as possible. In the middle of hot, dry days, insects are less active and less likely to come in contact with the insecticide. It will also be difficult to get good coverage of wilted plants, and heat will volatilize some insecticides before they reach the plant.

Using the most appropriate sprayer will also increase efficiency as only chemicals deposited on plant surfaces kill insects.

For aphids and other underleaf insects, only spray deposited on leaf undersides is effective. Conventional sprayers rely on gravity and inertia to deliver pesticides. By some estimates, only half the pesticide applied adheres to the plant.

Electrostatic Sprayers

Electrostatic sprayers which apply an electrical charge to the material being sprayed reduce spraying time and improve insect and disease control per unit of chemical applied.

The charged chemical is attracted to the opposite electric charge on the leaf surface so that retention is better. To further increase efficiency, the charged spray can be delivered with a turbulent air blast, carrying the material deeper into the plant canopy. Such air-assisted electrostatic sprayers deposited four times more spray onto both upper and lower leaf surfaces than conventional mist-blower equipment. Higher amounts of sprays from air-assisted electrostatic units were also found deeper in the crop canopy compared to the amounts delivered by uncharged hydraulic sprayers. These sprayers also deposit more spray on any fruit present in the canopy, however.

Some systemic insecticides are applied to the soil at planting to control early season insects. Thoroughly incorporating granules of these soil-applied chemicals increases control efficiency, while reducing hazards to birds and wildlife from surface granules and granules spilled at the ends of the rows.

Chemical Control in an IPM Program

Regular field scouting, coupled with forecasting pest problems and determining economic thresholds, is used to ensure that pesticides are only applied when pest populations warrant chemical control. The traditional approach of applying pesticides routinely or at the first sign of any crop pest is replaced with a philosophy that seeks to optimize crop growth and allow natural enemies of pests the opportunity to suppress the outbreak.

Producers and consumers must understand, however, that there is no "***silver bullet***" in an IPM program and that some level of pests and diseases must be tolerated. Fortunately, most crops can tolerate a certain level of infestation before significant yield or quality losses occur.

Weeds and Insects

Weedy areas may provide habitat for both pests and beneficial insects, but if plants in adjacent weedy areas are related to crop plants, weedy areas are more likely to be a source of insect pests. Morning glory is related to sweetpotato, for example, and nightshade to tomatoes, potatoes and eggplant. Pests with a wide host range such as armyworms, crickets, cutworms, darkling beetles, flea beetles, grasshoppers, lygus bugs, slugs and snails, stink bugs and thrips often inhabit weedy areas and in some cases will attack nearby crops.

Mowing weedy areas for the first time after the crop emerges may encourage migration onto crop plants. It may be best not to mow weedy areas at all or to mow before the crop emerges and regularly after emergence.

Tillage Practices and Insects

Plowing under plant debris to speed up decomposition is a common method to lower pest populations by destroying overwintering stages. Seed corn maggots, for example, survive in decomposing plant material. However, tillage operations will also reduce populations of beneficial insects. A study of field crops showed lower populations of carabid beetles and spiders in conventionally tilled fields compared to no-till fields. Both of these predators can help control seed and seedling pests. Strip tillage preserves habitat for beneficial insects, while still destroying soil-dwelling insects in the plowed area.

Crop Rotation

Crop rotation is a traditional production practice used to enhance soil fertility and tilt, increase crop vigor, and reduce the buildup of crop pests. Crop rotations cannot solve all weed, insect, and disease problems. However, without rotations, producers are essentially locked into pesticide-based control programs. Rotations are most likely to be effective on pests that tend to be crop specific and overwinter on site. By switching to another crop, pest cycles may be interrupted when they become active and find their food source is gone.

The key to a good rotation plan is to determine which pests are of most concern and then select crops accordingly. Obviously, market factors must be considered for producers to remain profitable. Continuous corn and alfalfa, as well as vegetable only and wheat-fallow cropping systems are common. These systems have some production and marketing advantages, but usually result in weed and other pest problems. Rotating to different crops, such as from vegetables to small grains, provides the additional benefit of scavenging excess soil nitrate.

IPM programs are difficult to implement under cropping systems that do not include rotations. Where rotation is practiced, pesticide use can often be greatly reduced with no significant losses. For example, corn rootworm insecticide is used in the greatest volume of any agricultural insecticide in the United States. Rotating corn fields to any other crop generally eliminates the need for insecticide application, saving money and reducing potential environmental impacts.

Resistant Crop Varieties

Plant breeders have been selecting pest resistant varieties to improve crop productivity for many years. Now, host plant resistance is a cornerstone of many successful IPM programs.

Non-chemical Pest Control Practices

IPM may result in reduced pesticide use by employing preventive pest management and non-chemical pest controls. Non-chemical pest management methods include crop rotation, resistant varieties, cultural practices, and biological controls. These methods are basic to effective IPM and should be the first line of defense. However, producers must plan for their use in advance of pest outbreaks to successfully use non-chemical management tools.

Plants have many natural characteristics for keeping pests at bay: repellent or toxic chemicals, thorns, hairs, and resistant tissues. The greatest plant breeding successes have been in the selection of disease resistant varieties, but insect tolerant lines have also been developed. With some pests, such as plant viruses, the only effective control is the use of resistant varieties and clean planting material. Resistant varieties will not interfere with other pest control measures and may reduce the need for pesticide treatment. However, resistance is not available for all problems. Potential drawbacks include decreased yields, increased susceptibility to other pests, and shifts in predominant pest biotypes as a result of over-exposure to the resistance genes.

Examples of pest resistant crops include Russian wheat aphid tolerant winter wheat, curly top virus resistant sugarbeets, European corn borer resistant corn hybrids, sorghum unpalatable to birds, and dry beans with tolerance to white mold and halo blight.

Nozzles

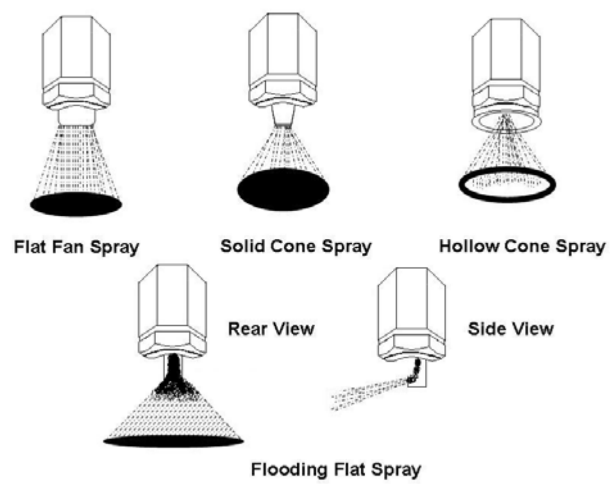
A variety of materials are used to make nozzles, including brass, stainless steel, ceramic and nylon. There are advantages and disadvantages with each type of material. However, it is wisest to invest in the best quality nozzles available. Brass nozzles are relatively inexpensive, but they wear rapidly with abrasive materials, such as wettable powders and liquid fertilizers. Stainless steel and hardened stainless steel are the most resistant to wear, but their expense discourages some users. Frequent replacement of brass nozzles usually makes their use more costly in relation to the area sprayed. The smooth surface of nylon nozzles makes them relatively resistant to wear, but the threads are easily damaged in use, especially when over tightened. Modified nylon tips in metal housings avoid some of these problems.

However, some solvents react with nylon, causing the material to swell and become unusable. Ceramic spray nozzles are also abrasion resistant, but are expensive and breakable. There are different types of spray patterns produced by nozzles each designed for a specific application. Choosing the proper nozzle for a particular treatment will ensure good coverage and minimum drift. The selection of a nozzle is determined by the type of treatment being applied as well as certain aspects of the spray equipment such as flow rate and operating pressure. Herbicides are applied at low pressure to produce large droplets that reduce drift.

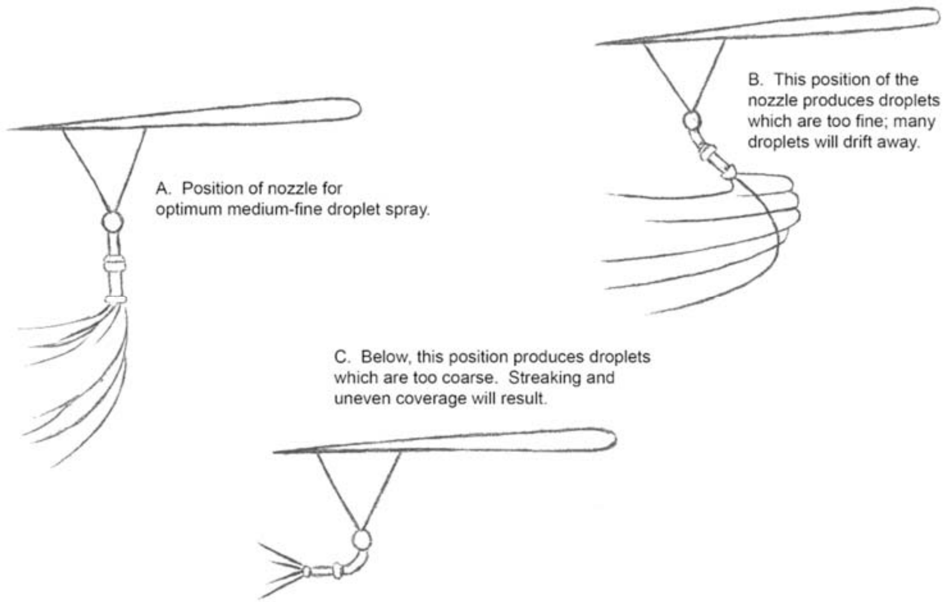
Higher pressures are used with fungicides to produce small droplets for better coverage of foliage. Insecticides are applied with pressure ranges between these two extremes. Drift control adjuvants work best with nozzles that reduce the number of fine and mist-like drops. To be effective and safe, nozzles may need to be changed for different pesticide applications.

Nozzle Section
Nozzles are a critical part of aircraft spray equipment. Their selection, location, calibration and testing are essential factors. The selection of nozzles is based on manufacturers' recommendations. Care must be exercised not to limit line pressure below 30 to 45 P.S.I. for water solutions. Special nozzles which entrain air or mix fluids in the tips are available. These are classified as foaming and bi-fluid systems. Nozzles for handling emulsions and slurries must have larger orifices.

Droplet Size
Droplet size is greatly affected by nozzle orientation on the boom. More shear and liquid break-up may be obtained by orienting nozzles with the direction of flight. A swivel action is desirable. Nozzle types, in order of break-up or particle size, are: (1) fine--hollow cone; (2) intermediate--flat fan; (3) coarse--solid cone.



Droplet size may also be controlled by the type of mixture being used (example: water emulsion or chemical wetting agent, etc.). Other influencing factors are the density, viscosity and surface tension of the liquid, and the evaporative conditions in the air between the point of release from the aircraft and the point of impingement on the ground.



For safety and economic considerations, positive shut-off control is essential. This may be attained through the use of diaphragm or ball check valves or a suction return control. Diaphragm nozzles are considered more efficient. All types require maintenance to ensure proper performance.

Rotary Spray Systems
Spray systems for rotary wing aircraft include tanks mounted on the side of the frame in line with the rotor shaft. A common cross pipe feeds the engine-driven pump. Filter, regulator and control valves are attached to the lower frame of the fuselage in view of the pilot. Boom and nozzles may be mounted on the rotor, frame, or toe of the skids, enabling the pilot to see them.

Granular Dispersal Systems
Granular dispersal systems are used for applying dust, impregnated granules, fertilizers and seed. A hopper with agitation must be provided to prevent bridging of fine material. Fine materials less than 60 mesh require agitators to prevent bridging. Frequent inspection of metering gates is required to ensure against leakage common under flight conditions of low pressure. The metering gate is the means of calibration. Size, shape, density and flowability of material all affect the swath width, application rate and pattern. The use of granular systems is on the decline in agricultural work.

Distance between Nozzle and Target (Boom Height)
Less distance between the droplet release point and the target will reduce spray drift. Less distance means less time to travel from nozzle to target and therefore less drift occurs.

Herbicide Volatility
All herbicides can drift as spray droplets, but some herbicides are sufficiently volatile to cause plant injury from drift of vapor (fumes). For example, 2,4-D or MCPA esters may produce damaging vapors, while 2,4-D or MCPA amines are essentially non-volatile and can drift only as droplets or dry particles.

Relative Humidity and Temperature Low relative humidity and/or high temperature will cause more rapid evaporation of spray droplets between the spray nozzle and the target than will high relative humidity and/or low temperature. Evaporation reduces droplet size, which in turn increases the potential drift of spray droplets.

Wind Direction and Velocity
Herbicides should not be applied when the wind is blowing toward an adjoining susceptible crop or a crop in a vulnerable stage of growth. The amount of herbicide lost from the target area and the distance the herbicide moves will increase as wind velocity increases, so greater wind velocity generally will cause more drift. However, severe crop injury from drift can occur with low wind velocities, especially under conditions that result in vertically stable air.

Spray Pressure
Spray pressure influences the size of droplets formed from the spray solution. The spray solution emerges from the nozzle in a sheet, and droplets form at the edge of the sheet. Increased nozzle pressure causes the sheet to be thinner, and this thinner sheet will break into smaller droplets than from a sheet produced at lower pressure.

Also, larger orifice nozzles with high delivery rates produce a thicker sheet of spray solution and larger droplets than smaller nozzles.

Communication
The majority of drift complaints pertain to trees, shrubs and ornamentals. Communicating with non-agricultural rural residents may reduce complaint submissions originating from lack of knowledge of products used and injury symptoms.

Other components
Flow control devices are necessary to make the tank, pump and nozzles work together. Depending on the application system, these devices may include pressure regulators, unloader valves and control valves. Because both the spray pattern and flow rate are determined by operating pressure, each sprayer should be equipped with a pressure gauge.

The gauge should be placed where it may be easily seen. Strainers are also required for effective treatments. Strainers trap particles and debris in the spray mixture and protect the pump, control devices and nozzles from damage.

Dispersal Summary

All nozzles produce a range of droplet sizes. The small, drift-prone particles cannot be eliminated but can be reduced and kept within reasonable limits.

Here are some tips:

- Select low or nonvolatile pesticides.
- Read and follow the pesticide label. Instructions on the pesticide label are given to ensure the safe and effective use of pesticides with minimal risk to the environment. Each pesticide is registered for use on specific sites or locations. Surveys indicate approximately 65 percent of drift complaints involved application procedures in violation of the label.
- Apply a pesticide only if economic thresholds warrant an application.
- Use spray additives within label guidelines. This will increase the droplet sizes and pesticide effectiveness.
- Use larger orifice sizes. This will give larger droplets and will increase the number of tank refills, but will improve coverage and effectiveness.
- Avoid high pressure. High pressure creates finer droplets; 45 PSI should be considered maximum for conventional broadcast spraying.
- Use drift-reduction nozzles. They will produce larger droplets when operated at low pressures.
- Use wide angle nozzles, low boom heights, and keep the boom stable.
- Drift is minimal when wind velocity is less than 10 mph. Do not spray when wind is greater or blowing towards sensitive crops, gardens, dwellings, and livestock or water sources.
- Use shielded booms. When banding, use shroud covers.

Pesticide applicators and others, including landowners, play a very important role in pesticide application -- deciding whether or not to apply a pesticide and if so how best to make that application. It is their responsibility to know and understand a product's use restrictions. They are responsible for complying with all other pesticide laws regarding pesticide applications and ensuring that their application equipment and techniques will produce a minimum of spray drift. The EPA also expects applicators to exercise a high level of professionalism in making decisions about applications.

Drift Control

The EPA defines spray or dust drift as:
"the physical movement of pesticide droplets or particles through the air at the time of pesticide application or soon thereafter from the target site to any non- or off-target site. Spray drift shall not include movement of pesticides to non- or off-target sites caused by erosion, migration, volatility, or windblown soil particles that occurs after application or application of fumigants unless specifically addressed on the product label with respect to drift control requirements."

This definition is based on a definition of spray drift composed by participants of the National Coalition on Drift Minimization, which include representatives from federal (including the EPA and the U. S. Department of Agriculture) and state agencies and tribes, pesticide and equipment manufacturers, university scientists, and others, who have focused their attention on enhancing pesticide applicator education, application research, and regulatory initiatives to foster reductions in spray drift.

The Agency recognizes that pesticide vapor and the off-target movement of pesticides by other means, not included in this definition, can nevertheless present substantial risks to humans and the environment. The EPA generally addresses these routes of exposure and associated risk at the individual pesticide level through its regulatory programs.

This definition was used in Pesticide Registration Notice (**PR NOTICE 2001-X**) put out by the EPA on 12/19/01.

What Is Pesticide Spray Drift?
The EPA defines pesticide spray drift as the physical movement of a pesticide through air at the time of application or soon thereafter, to any site other than that intended for application (often referred to as off target). The EPA does not include in its definition the movement of pesticides to off-target sites caused by erosion, migration, volatility, or contaminated soil particles that are windblown after application, unless specifically addressed on a pesticide product label with respect to drift-control requirements.

How Does Spray Drift Occur?
When pesticide solutions are sprayed by ground spray equipment or aircraft, droplets are produced by the nozzles of the equipment. Many of these droplets can be so small that they stay suspended in air and are carried by air currents until they contact a surface or drop to the ground. A number of factors influence drift, including weather conditions, topography, the crop or area being sprayed, application equipment and methods, and decisions by the applicator.

What Are the Impacts of Spray Drift?
Off-target spray can affect human health and the environment. For example, spray drift can result in pesticide exposures to farmworkers, children playing outside, and wildlife and its habitat. Drift can also contaminate a home garden or another farmer's crops, causing illegal pesticide residues and/or plant damage.

The proximity of individuals and sensitive sites to the pesticide application, the amounts of pesticide drift, and toxicity of the pesticide are important factors in determining the potential impacts from drift.

How Does the EPA View Off-Target Spray Drift?
The EPA recognizes the importance of exposures to pesticides resulting from spray drift. There are thousands of reported complaints of off-target spray drift each year.

Reports of exposures of people, plants, and animals to pesticides due to off-target drift (often referred to as "***drift incidents***") are an important component in the scientific evaluation and regulation of the uses of pesticides. Other routes of pesticide exposure include consuming foods and drinking water which may contain pesticide residues, applying pesticides, and contacting treated surfaces in agricultural, industrial, or residential settings. The EPA considers all of these routes of exposure in regulating the use of pesticides.

Off-Target Drift
When labels of pesticide products state that off-target drift is to be avoided or prohibited, our policy is straightforward: pesticide drift from the target site is to be prevented. However, we recognize that some degree of drift of spray particles will occur from nearly all applications.

Nevertheless, applicators and other responsible parties must use all available application practices designed to prevent drift that will otherwise occur. In making their decisions about pesticide applications prudent and responsible applicators must consider all factors, including wind speed, direction, and other weather conditions; application equipment; the proximity of people and sensitive areas; and product label directions.

A prudent and responsible applicator must refrain from application under conditions that are inconsistent with the goal of drift prevention, or are prohibited by the label requirements. The EPA uses its discretion to pursue violations based on the unique facts and circumstances of each drift situation.

How Does EPA Help Protect People and the Environment from Off-Target Spray Drift?
The EPA is responsible for a number of important programs that help protect people and the environment from potential adverse effects that can be related to off-target drift from pesticide applications. These programs include restricting how pesticides are used, certification and training of applicators, and enforcement and compliance of pesticide laws.

Restricting How Pesticides are Used
Under Federal law, the EPA's Office of Pesticide Programs is responsible for evaluating pesticides and their uses to ensure that they can be used with a reasonable certainty of no harm to human health and not cause unreasonable risks to the environment when properly applied.

In fulfilling these duties, the EPA considers the potential impact of spray drift on humans and the environment in our evaluations of proposed pesticides for new registration and older, existing pesticides for re-registration.

As a part of the EPA's evaluation of a pesticide, the EPA estimates the amounts of off-target drift and the associated potential risks to human health and the environment. Restrictions on a pesticide's application may be triggered in two ways. For new pesticides and existing pesticides undergoing re-registration, estimated deposition levels are evaluated along with the pesticide's toxicity.

For existing pesticides, available information on drift incidents is also evaluated. Based on these evaluations, the OPP may impose specific restrictions for a pesticide's application.

Specific Restrictions

Specific restrictions may include prohibiting the use of certain pesticides under certain conditions, prohibiting certain methods of application, requiring use of a foliage barrier, or requiring a buffer zone distance between the site of application and areas to be protected.

In general, applicators must use all available drift prevention practices in order to prevent drift. During the past few years, the OPP has received and reviewed new studies on spray drift that it required from pesticide registrants to support their product registrations. The OPP has completed its review of these studies and reached conclusions about the factors that influence drift and the amounts of sprays which can drift from the application site.

U.S. Department of Agriculture

The OPP also collaborated under a cooperative research and development agreement with registrants and the U.S. Department of Agriculture (**USDA**) on the development of a model ("***AgDRIFT***") to predict distances of spray drift under many different conditions.

To ensure the scientific quality of the conduct of the studies, the conclusions that were drawn from these studies, and the predictive model, the OPP obtained independent expert peer reviews, including the Federal Insecticide, Fungicide, and Rodenticide Act (**FIFRA**), Science Advisory Panel.

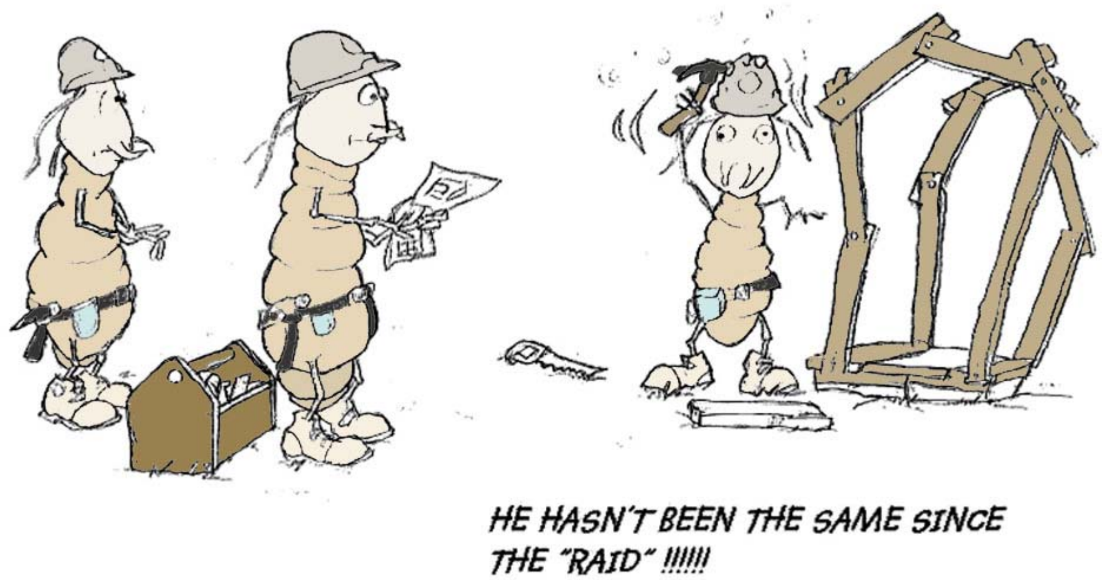
These expert peer reviews supported the use of the model and these studies for the OPP's science assessments of pesticides.

Based on these studies and reviews, the OPP is now developing improved product labeling to inform applicators of requirements to control off-target spray drift. The OPP plans to publish these requirements and an implementation plan in a draft notice (PR Notice) this winter and ask for public comments.

Where Can Complaints About Spray Drift Be Directed?

If you believe that you have been exposed to pesticide spray drift and have health-related questions, you should contact your physician, local poison control center, or health department for assistance.

You can also contact the National Pesticide Information Center.



Each worker is instructed how to put on, use, and remove the personal protective equipment and is informed about the importance of washing thoroughly after removing personal protective equipment.

(x) Each worker is instructed in the prevention, recognition, and first aid treatment of heat-related illness.

(xi) Workers have a clean place(s) away from pesticide-storage and pesticide-use areas for storing personal clothing not in use; putting on personal protective equipment at the start of any exposure period; and removing personal protective equipment at the end of any exposure period.

(7) When personal protective equipment is required by the labeling of any pesticide for early entry, the agricultural employer shall assure that no worker is allowed or directed to perform the early-entry activity without implementing, when appropriate, measures to prevent heat-related illness.

Drift Hazards

Spray or dust drift is one of the greatest hazards of aerial application in terms of pesticide misuse. The amount of drift depends upon three factors. They are: (1) the size of the droplets or particles; (2) the wind velocity; and (3) the height above the ground from which the pesticide is released.

Droplet size depends primarily upon the spray pressure, nozzle design and orientation, and the surface tension of the spray solution. The size of granular materials depends upon the particular formulation and can be controlled to some extent by screening. In the case of sprays, droplet size is generally increased by reducing pressures or increasing nozzle size. The use of surfactants tends to lower the surface tension of a spray solution and usually results in a smaller droplet size than when the same formulation is used without a surfactant.

High wind velocities obviously increase the drift hazard as they carry the small droplets and particles away from their intended target. In many cases the distance can run into several miles. Winds tend to be least turbulent just before sunrise or just after sunset. The most gusts usually occur between 2 and 4 p.m. A 3 mile per hour wind is usually the maximum wind velocity which is recommended for aerial applications.

The height from which a pesticide is released is important because it affects the time required for the droplet or particle to reach the ground. The longer the time required, the more opportunity there is for the pesticide to move away from its intended target. It is also true that the wind velocity is lower close to the ground than at higher elevations. Therefore, the wind problem can also be minimized by holding the discharge height to a minimum.

Every possible effort should be made to control pesticide drift. The distances can be surprising. Table 1 shows the effect of particle size on pesticide drift. In general, the ideal size of particles for aerial pesticide application is 500 to 1000 microns. This will permit adequate coverage with minimum drift problems.

Table 1: Effect of Particle Size on Pesticide Drift

Droplet or Dust Particle Diameter (microns)	Distance of Drift*
0.5	388 miles
2	21 miles
5 (Fog)	3 miles
10	1 mile
100 (Mist)	409 feet
500 (1/50 inch) (Light Rain)	7 feet
1000 (1/25 inch) (Moderate Rain)	4.7 feet

**Pesticide released 10 feet above ground in a 3mph wind*

Information Centers

The OPPTS Chemical Library supports programs under the Toxic Substances Control Act (**TSCA**) and the Emergency Planning and Community Right-to-Know Act (**EPCRA**). The Library's special collections include works on specialty subjects such as pollution prevention, biotechnology, and risk assessment.

A list of other libraries in the EPA National Library Network
OPP's Freedom of Information Act site provides information on FOIA and procedures for requesting a document from the EPA through the Act.

The OPP Public Regulatory Docket provides the public with access to pesticide related information produced by the EPA. Three individual dockets--Federal Register, Special Review, and Special Programs dockets--house regulatory notices, background documents and public comments on OPP activities.

The National Service Center for Environmental Publications (**NSCEP**) is a central repository for all EPA documents with over 5500 titles in paper and/or electronic format, available for distribution. You can browse and search the National Publications Catalog and order EPA Publications online or by telephone at 1-800/490-9198.

Resources

Government Agencies

- CDC, Center for Disease Control & Epidemiology http://www.cdc.gov/
- CPSC, Consumer Product Safety Commission http://www.cpsc.gov/
- EPA-OAR, EPA Office of Air & Radiation http://www.epa.gov/oar/
- EPA-OPP, EPA Office of Pesticide Programs http://www.epa.gov/pesticides/
- FDA, Food and Drug Administration http://www.fda.gov
- NCID, National Center for Infectious Disease http://www.cdc.gov/ncidod/ncid.htm
- NCSICP, North Carolina Statewide Infection Control Program http://www.unc.edu/depts/sicp/
- NIH, National Institutes of Health http://www.nih.gov/index.html
- NTP, National Toxicology Program http://ntp-server.niehs.nih.gov/default.html/
- OSHA, Occupational Safety and Health Administration http://www.osha.gov
- USDA, United States Department of Agriculture, http://www.usda.gov

Educational/Research Groups

- ChemFinder, Cambridge Software http://chemfinder.cambridgesoft.com/
- EXTOXNET, Extension Toxicology Network http://ace.orst.edu/info/extoxnet/
- NPIC, National Pesticide Information Center http://ace.orst.edu/info/nptn/

Chemicals

- Emergency Care Information (*Alcohols): http://www.embbs.com/cr/alc/alc.html
- Ethylene Oxide: http://ntp-server.niehs.nih.gov/htdocs/ARC/ARC_RAC/Ethylene-oxide.html
- Toxicology and Carcinogenesis Studies of Ethylene Oxide: http://ntp-server.niehs.nih.gov/htdocs/LT-studies/tr326.html
- Formaldehyde: http://www.pp.okstate.edu/ehs/training/oshafhyd.htm
- TR-490 Toxicology and Carcinogenesis Studies of Glutaraldehyde: http://ntp-server.niehs.nih.gov/htdocs/LT-studies/tr490.html

- (*Hypochlorites & Chlorine) Use of Bleach in Prevention of Transmission of HIV in Health Care Settings: http://www.cdc.gov/od/ohs/biosfty/bleachiv.htm

Chemical Searches
- Chemfinder Webserver: http://chemfinder.camsoft.com/
- EXTOXNET http://ace.ace.orst.edu/info/extoxnet
- Various Factsheets http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm

Bloodborne Pathogen Standard
- OSHA Occupational Safety and Health Standards 1910: http://www.osha-slc.gov/OshStd_toc/OSHA_Std_toc_1910.html
- OSHA Bloodborne Pathogen Standard 1910.1030: http://www.osha-slc.gov/OshStd_data/1910_1030.html
- Interpretation-Compliance Letter, Bleach Solutions: http://www.osha.gov/OshDoc/Interp_data/I19920728A.html
- Bloodborne Pathogens and Acute Care Facilities (Many regional contacts): http://www.osha-slc.gov/Publications/OSHA3128/osha3128.html

Disinfection MSDS:
- http://www.pp.okstate.edu/ehs/modules/msds.htm

Pathogens
- All the Virology on the WWW: http://www.tulane.edu/~dmsander/garryfavweb.html
- The Bad Bug Book: http://vm.cfsan.fda.gov/~mow/intro.html

Pesticide/Insect Glossary

Acaricide: A pesticide used to control mites and ticks. Same as miticide.
Adhesive: A substance which will cause a spray material to stick to the sprayed surface, e.g., sticking agent.
Adjuvant: Any substance added to pesticide which improves the activity of the active ingredient. ***Examples***: Penetrates, spreader-stickers and wetting agents.
Adventive: Located outside habitat, though an reproductive population may not be established.
Alates: Winged forms of insects.
Anthocorids: A true bug in the family Anthocoridae.
Aphid: An insect in the family Aphididae which is sometimes called plant lice.
Algaecide (Algicide): A pesticide used to kill or inhibit the growth of algae.
Alien: Same as non-native.
Anti-Transpirant: A chemical applied directly to a plant which reduces the rate of transpiration, or water loss, by the plant.
Avicide: A chemical used to kill birds.
Bactericide: Chemical used to kill bacteria.
Band Application: The application of a pesticide or other material to a limited area such as in or beside a crop row rather than over the entire field area.
Beneficial insect: Any insect that has a life style that is advantageous to man. Insects that preserve the balance of nature by feeding on others, pollinators, and recyclers are examples of beneficial insects.
Cephalothorax: Head (ceph) and chest (thorax) area.
Cerci: Paired appendages on the end of the abdomen of many insects which are used for sensing, defense or mating.
Chewing (mouth parts): Any mouth part that literally bites to feed; other mouth part types are sucking and rasping.
Clavus: The enlarged terminal antennal segments that form a club
Collophore: A tube-like structure on the underside of the first abdominal segment (folds under the body) of Collembola (e.g. springtails) which is used as a spring action for leaping.
Broad Spectrum Application: General purpose pesticides which can be used against a large number of pests on a wide range of crops.
Broadcast Application: The application of a pesticide or other material over the entire field or area.
Calibrate: To determine the amount of pesticide that will be applied to the target area.
Colonizing: An ant species which is successful at creating nests in new areas. While some exotic ants are successful colonizers, many colonizing species are not exotic -- and many exotics are not colonizers.
Compound eyes: The large multi-faceted eyes of insects.
Coreids: A member of the family Coreidae, which are leaf footed bugs**.**
Corium: The elongate, thickened basal portion of the fore wing of Hemiptera.
Cornicles: Tubular structure on each side of abdominal region from which pheromones or honeydew is expelled.
Coxa (pl.=coxae): Basal portion of the leg.
Crepuscular: Having activity periods during low light levels at dawn and evening.
Cursorial: Adapted for running.
Coverage: Spread of a pesticide chemical over a surface such as the leaves, fruit, stem, etc.

Dactyl: Literally, a finger or fingerlike projection on an insect body part.
Dealates: Winged forms that have shed their wings, like reproductive termites or ants.
Defoliate, defoliation: Removal of foliage from plants, often by chewing insects.
Detritivore: Any organism that eats decaying organic matter.
Diapause: An insect resting stage, usually induced by environmental signals or extreme conditions like winter or summer.
Dimorphic: Having two distinct forms.
Defoliant: A chemical which causes the leaves or foliage to drop from a plant.
Desiccant: A chemical that promotes drying or loss of moisture.
Drift: The airborne movement of a pesticide spray or dust from the target area to an area not intended to be treated.
Dust: A finely ground, dry pesticide formulation usually containing a small amount of active ingredient and a large amount of inert carrier or dilutent such as clay or talc.
Emulsifiable Concentrate: A pesticide formulation produced by dissolving the active ingredient and an emulsifying agent in a suitable solvent. When added to water, an emulsion (milky mixture) is produced.
Endosperm: A portion of a seed which contains most of the energy reserves for germination.
Estivation (aestivation) : A resting stage (quiescence) resulting from continued high temperature or xeric conditions; diapause; hibernation.
Exoskeleton: The outer portion of an insect body which may be relatively soft like a caterpillar or hardened like many beetles.
Femora: A segment of an insect leg; usually the largest segment.
Filiform: Linear shaped, as the antennae of ground beetles.
Forbs: Any broadleaf non-woody (herbaceous) plant.
Frass: Solid larval insect excrement; plant fragments made by wood-boring insects, usually mixed with excrement.
Furculum (plural: furcula): The elongate fork-like appendage on the end of the abdomen. **Exotic**: Same as non-native.
Eradication: The complete elimination of either weeds, insects, disease organisms, or other pests from an area.
Fumigant: A chemical that forms vapors (gases) which is used to destroy weeds, plant pathogens, insects or other pests.
Fungicide: A chemical that kills or inhibits fungi.
gpm.: Gallons per minute.
Genera: Plural of genus; A genus is a group of plants or animals with similar characteristics. Animals (insects) are classified by kingdom, phylum, class, order, family, genus, species, and author's name. For example, the honey bee is classified as Animal (kingdom), Arthropoda (phylum), Insecta or Hexapoda (class), Hymenoptera (order), Apidae (family), *Apis* (genus), *mellifera* (species), Linnaeus (author's name). The genus and species are always italicized.
Girdle, girdling: Damage of a plant that circles the stem or branch cutting off the connective plant tissue.
Grigology: The study of crickets, grasshoppers and katydids.
Hemelytron: The first wing of a true bug (Hemiptera) which has the base more thickened than the membranous outer portion.
Hopperburn: Leaf damage caused by leafhopper feeding, which is a yellowing of the leaves.
Herbicide A pesticide used for killing or preventing plant growth. A weed or grass liquid.
Imago: The adult stage of an insect.
Instar: An insect stage between molts; molting is growth.

Internode: The part of a plant stem between the nodes. Nodes mark the point of attachment of leaves, flowers, fruits, buds and other stems.
Insecticide: A pesticide that is used to kill, inhibit, repel or otherwise prevent damage by pests.
Introduced: Same as non-native.
Invasive: A species which is spreading its geographic range into niches occupied by other species. Documentation of an invasive species requires an ecological study to demonstrate the displacement of other ants.
Larval stage (larva, larvae): An immature insect, sometimes used to include all immature stages, even eggs. Usually this term refers more specifically to the feeding stages of insects with complete metamorphosis like grubs, caterpillars, and maggots.
Maggot: In most Diptera (flies), legless larva lacking a distinct head, with cephalic (head) end pointed and caudal (rear) end blunt.
Mesophyll: Fleshy plant tissue inside a leaf or stem.
Metamorphosis: **-** change in form during an insect's growth and development.

Gradual metamorphosis - incomplete metamorphosis in which there is no pupal stage and the immatures and adults look similar excluding the wings of the adults.
Incomplete metamorphosis - any metamorphosis type that does not include the pupal stage. Incomplete metamorphosis is present in Orthoptera (grasshoppers), Hemiptera (true bugs), and several other orders.
Simple metamorphosis - any metamorphosis that occurs in insect groups where they are not winged and have no pupal stage. Insect groups with simple metamorphosis include the Collembola (springtails) and Thysanura (silverfish).

Metathorax: The second section of the insect thorax which houses the second pair of legs and the first pair of wings.
Mite: A member of the order Acari (ticks and mites)
Molt, molting process: In insects, as in snakes, the process of shedding the exoskeleton.
Naiad: A term for immature insects that are aquatic from the orders Plecoptera, Odonata, and Ephemeroptera. This term is becoming archaic and is now replaced by the more general term "***immature***" insect.
Necrosis: Death of tissue in plants or animals.
Nymphs: An immature stage of hemimetabolous insects (those with incomplete metamorphosis).
Microbial Pesticide: Bacteria, viruses, fungi and other microorganisms used to destroy or control pests.
Miticide: See acaricide.
Molluscicide: A chemical used to kill or control snails and slugs.
Native: These definitions do not necessarily define *where* a species is native. How do I define where a species is native? Sometimes the non-native status of a species is clear from previous collections and existing knowledge from biogeography and systematics. Other times, boundaries are a lot blurrier. Is a species non-native if it has been there for 400 years?
Nematicide: A pesticide that kills or otherwise controls nematodes.
Non-indigenous: Same as non-native.
Non-native: A species which is established outside its native habitat. With respect to ants, ants with an established reproducing colony.
Oothecae: A bean-like hardened egg capsule produced by female cockroaches.
Osmeterium (pl.=osmeteria): Scent-producing area behind the tibia.
Overwinter: Time spent during the winter months. Insects are often in hibernation or at least rather immobile in the colder temperatures.

Ovipositor: The egg laying apparatus of an insect. The stinger of a bee is actually a modified ovipositor.
Parthenogenesis: Egg development without fertilization.
Pedipalps: Second pair of appendages of the cephalothorax corresponding to the mandibles of insects.
Petiole: Attachment of a leaf to stem.
Phloem and xylem: Vascular tubes that allow fluid transport in plants. It is the way plants receive and distribute nutrients, hormones and water.
Photosynthesis: The chemical process that plants use to convert carbon dioxide and water to sugars and ultimately to energy.
Phyto- (prefix): Plant.
Phytophagous: Plant eating; an insect using plants as a food source.
Phytotoxemia: A toxic reaction in plants.
Poikilotherm: A cold-blooded organism.
Proboscis: A nose, or, in the case of butterflies, the coiled sucking mouthpart.
Pronotum: The plate on top of the prothorax.
Prothorax: The front part of an insect thorax which includes the attachment points for the front legs.
Protozoan: A microorganism in the kingdom Protozoa.
Pseudergates: Caste found in the lower termites (Isoptera), comprised of individuals having regressed from nymphal stages by molts eliminating the wing buds, or being derived from larvae having undergone non-differentiating molts, serving as the principle elements of the worker caste, but remaining capable of developing into other castes by further molting.
Psocids: Any insect in the order Psocoptera, which includes booklice and barklice.
Psyllid yellows: A virus disease of potatoes, tomatoes, peppers, and eggplant. See purple top.
Pupal stage (pupa): The stage in complete metamorphosis between larva and adult like the cocoon in moths.
Purple top: A purple discoloration of foliage tips caused by insect transmitted virus.
Pustulate: Pus-forming, as in spider bites.
Pesticide: A chemical or other agent used to kill or otherwise control pests.
Pisicicide: A chemical used to kill undesirable fish.
Postmergence: After the plants have appeared through the soil.
Protectant: A pesticide applied to a plant or animal prior to the appearance or occurrence of the pest in order to prevent infection or injury by the pest.
Repellant: A compound that keeps or drives away insects, rodents, birds or other pests from plants, domestic animals, buildings or other treated areas.
Rhopalid: An insect in the family Rhopalidae in the order Hemiptera (true bugs).
Rosetting: Malformation of a plant resulting in a bunched irregular growth of the leaves.
Rodenticide: A pesticide, or mixture of pesticides, used to kill or control rodents.
Scutellum: A triangular shaped section on the back of Hemiptera and some Coleoptera. It is often the identifying characteristic of Hemipterans or "***true bugs***".
Secondary reproductive: A caste of subterranean termite; also called supplemental reproductives. If these termites develop from nymphs, they are called secondary reproductives (primary reproductives are the king and queen). If they develop from pseudergates, they are called tertiary reproductives. Supplementals may be responsible for most of the egg production in the colony.
Spinneret: A small tubular appendage from which silk threads by spiders and many larval insects are excreted.

Stippling (leaf): A speckled appearance of a leaf, usually yellowish spots on a green leaf.
Stolon: An underground portion of a plant that grows horizontally, like a grass root.
Subgroup: A subset of a group with related characters. The term group is a general and non-specific collection of similar organisms regardless of taxonomic hierarchy.
Subimago: The first winged stage of a mayfly. This is the only group to have a winged stage that molts. The final stage is the imago, or adult.
Silvicide: A pesticide used to destroy woody shrubs and trees.
Soluble Powder: A finely ground, solid material which will dissolve in water or some other liquid carrier.
Space Spray: A pesticide which is applied as a fine spray or mist to a confined area either indoors or outside.
Target: The plants, animals, structure, areas or pests to be treated with a pesticide application.
Tarsi: A foot. Insect feet are made of several segments and may have pads, hairs, or hooks.
Tegmina: Plural of tegmen, a hardened covering like the forewing of many Orthoptera and Hemiptera.
Tenaculum: A minute two-pronged structure on the underside of the third abdominal segment of Collembola (springtails) which holds the furcula (appendage used for jumping) before it is released to jump.
Termite: Any wood-eating insect in the order Isoptera.

soldier termite - a caste of termites with specific structures to defend the colony, such as large mandibles or nasute mouths that produce sticky defensive substances.
worker termite - a caste of termites that do most of the work in the colony. Worker termites can be all immature termites and forms that do not develop into reproductive forms or soldiers.

Tertiary reproductive termite: See secondary reproductive.
Tettigoniid: A family of Orthoptera, often called long-horned grasshoppers, which includes katydids.
Thorax: The second body segment of an insect. The thorax has all of the wings and legs attached to it.
Tip burn: A yellow or dried tip on a branch or leaf caused by insect feeding or a plant physiology disorder.
True bugs: Insects in the order Hemiptera. They are usually characterized by a scutellum, a triangular shaped section on the back.
Tramp: A widespread ant species spread by human commerce with a specific syndrome of life history characteristics: extreme polygyny, unicolonial or highly polydomous nest structure and colony reproduction by budding (sensu Passera 1994).
Transferred: Collected outside native habitat, without knowledge of established nests.
Transported: Same as transferred; often refers to animals found in quarantine inspection.
ULV: Ultra Low Volume. No water is applied with this pesticide formulation. Spray concentrates are frequently used in ULV applications.
Venation: The pattern of veins in the insect wing.
Wettable Powder: A solid (powder) pesticide formulation which forms a suspension when added to water.

Agricultural plant means any plant grown or maintained for commercial, research, or other purposes. Included in this definition are food, feed and fiber plants, trees, turf grass, flowers, shrubs, ornamentals, and seedlings (40 CFR).

Farm means any operation, other than a nursery or forest, engaged in the outdoor production of agricultural plants (40 CFR, Section 170.3).

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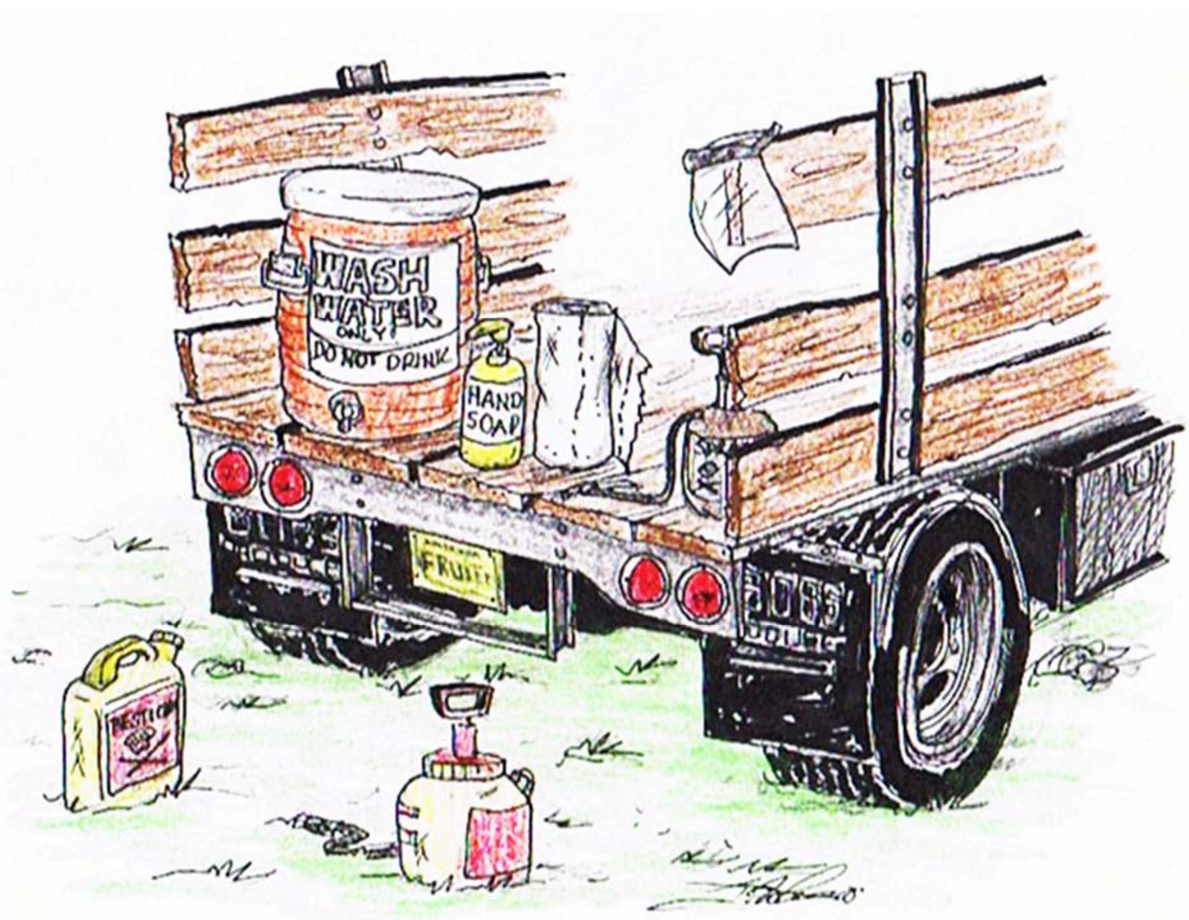

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Plant Glossary

Abaxial – a. (L. *ab*, from; *axis*, axle) that surface of any structure which is remote or turned away from the axis, such as the lower surface of a leaf.
Absorption - The process by which a filter media traps unwanted molecules.
Acaulescent - a. (Gr. *a*, without; *kaulos*, stalk) having no stem or seemingly without a stem.
Accessory flower parts - Sepal and petal organs found on flowers. The sepals and petals are not essential for pollination, but may aid in attracting insects or other organisms.
Achene - n. (Gr. *a*, not; *chainein*, to gape) any small, dry fruit with one seed whose outer covering (pericarp) does not burst when ripe.
Acicular - a. (L. *acicula*, a small needle) slender and pointed; needle-like with a sharp point.
Acidic - Water with a pH of less than 7.
Acropetal - a. (Gr. *akros*, summit; L. *petere*, to seek) developing upward from the base toward the apex.
Acrylic - A plastic material used to construct fish tanks, filters and accessories.
Actinomorphic - a. (Gr. *aktis*, ray; *morphe*, form) descriptive of a flower or set of flower parts which can be cut through the center into equal and similar parts along two or more planes; having radial symmetry.
Aculeus - n. (L. *aculeus*, prickle) a prickle growing from bark. pl. aculei**.**
Acumen - n. (L. *acumen*, a point, a sting) the point of an acuminate leaf.
Acuminate - a. drawn out into a long point; tapering point.
Acute - a. (L. *acutus*, sharpened) sharp at the end; ending in a sharp point.
Adaxial - a. (L. *ad*, to; *axis*, axle) pertaining to the side of an organ toward the axis, such as the upper surface of a leaf.
Adipose Fin - A small fin located behind the dorsal fin and in front of the caudal fin.
Adnate - a. (L. *adnatus*, to be born, to grow to) fusion of unlike structures or parts.
Adsorption - The process by which filter media attracts unwanted molecules to its surface via a chemical charge.
Adventitious - a. (L. *adventitius*, extraneous) plant structures or tissue occurring in an abnormal position.
Adventitious plant - Able to exist either on land or in the water.
Adventitious root - Root which develops from the node of a stem or similar organ, such as a Rhizome, Stolan or runner.
Adventive - a. (L. *advenire*, to arrive) a plant that is not native to the environment.
Aerenchyma - n. (Gr. *aer*, air; *enchyma*, an infusion) parenchyma tissue with large and abundant intercellular air spaces; air-storing tissue; resembles the tissue of cork.
Aerobic - An organism that needs oxygen to survive.
Aggregate - a. (L. *ad*, to; *gregare*, to collect into a flock) crowded into a cluster; a number of separate fruits from a single flower aggregated together; an aggregate flower is formed by a cluster of carples.
Airstone - A device that attaches to the air pump to create various bubble effects.
Alimentary canal - The tube of the digestive system through which food passes; where digestion takes place.
Alkaline - Water with a pH between 7 and 14. Also known as Basic.
Allele - n. (Gr. *allelon*, one another) one of a pair or more of alternative hereditary characters; a gene which can occupy the same locus as another gene in a particular chromosome.

Allelochemicals - compounds that have an allelopathic effect.
Allelopathy - n. (Gr. *allelon*, one another; *pathos*, suffering) the influence or effect of one living plant upon another; refers to biochemical interaction between all types of plants and its effect depends on a chemical compound being added to the environment.
Alternate - a. (L. *alteratus*, one after another) said of leaves occurring one at a node; said also of members of adjacent whorls in the flower when any member of one whorl is in front of or behind the junction of two adjacent members of the succeeding whorl.
Alternation of generations - the occurrence in one life history of two or more different forms differently produced, usually an alternation of a sexual with an asexual form.
Alveola - n. (L. *alveolus*, small cavity) a pit on the surface of an organ.
Alveolate - a. (L. *alveolatus*, pitted) deeply pitted so as to resemble a honeycomb, as are the surfaces of some seeds or achenes.
Ammonia (NH3) - A dissolved gas that even in low concentrations is toxic to fish. It is produced by the breakdown of organic waste products.
Anaerobic - A term used to describe an organism that lives in an environment with little or no oxygen.
Anaerobiosis - n. (L. Gr. *an*, without; *aer*, air; *biosis*, manner of life) life in the absence of air or free oxygen; anaerobic respiration, respiration occurring in the absence of oxygen.
Anal fin - Single fin mounted vertically below the fish.
Anastomosis - n. (Gr. *ana*, up to; *stoma*, mouth) connecting by cross-veins and forming a network.
Anatomy - n. (LL. *anatomia*, dissection) the branch of morphology that deals with the structure of plants, esp. the internal structure as revealed by the microscope.
Androecium - n. (Gr. *andros*, man; *oikos*, house) male reproductive organs of a plant; a collective term applied to all structures of the stamen whorl or whorls.
Androgynal - a. (Gr. *andros*, man; *gonos*, woman) bearing staminate and pistillate flowers on the same parent stem.
Androgynous - staminate flowers above the pistillate flowers in the same inflorescence.
Androphore - n. (Gr. *aner*, man; *phoros*, carrying) a support or column, formed by fusion of filaments, on which the stamens are borne.
Anemophily - n. (Gr. *anemos*, wind; *philein*, to love) pollination by wind.
Angiospermae - n. (Gr. *anggeion*, vessel; *sperma*, seed) a major division of the plant kingdom, commonly called flowering plants (as their reproductive organs are in flowers,) having seeds which develop in a closed ovary made of carpels, a very reduced gametophyte, and endosperm develop from a triple fusion nucleus. pl. Angiosperms.
Annual - a. (L. *annualis*, yearly, from *annus*, year) a plant which completes its life history within a year.
Anoxia - n. (L. *an*, not; and oxygen) lack of oxygen or not enough oxygen.
Anther - n. (Gr. *antheros*, flowery, from *anthein*, to bloom) the top of the stamen, usually elevated by means of a filament, which contains the pollen.
Anthesis - n. (Gr. *anthesis*, bloom, from *anthein*, to bloom) stage or period during which the flower bud is fully open; flowering.
Antrorse - a. (L. *ante*, before; *vertere*, to turn) forward or upward.
Apetalous - a. (Gr. *a*, without; *petalon*, leaf) having flowers without petals; having no corolla.
Apical - a. (L. *apex*, the tip or top of a thing) at the tip or summit.
Apical bud - The principal growing point of the stem.
Apiculate - a. (LL. *apiculatus*, point) terminated abruptly by a small, distinct point, an apiculus or apicule.
Apocarpous - a. (Gr. *apo*, away; *karpos*, fruit) having separate carpels.

Apomixis - n. (Gr. *apo*, away; *mixis*, a mixing) in general, reproducing without sexual reproduction; often used to denote seed production without a sexual process having been involved.
Appressed - a., adv. (L. *ad*, to; *pressare*, to press) lying flat or close against something. Often used for hairs.
Aquatic plants - plants that must grow in water whether rooted in the mud or floating without anchorage; plants that must complete part or all of their life cycle in or near the water.
Aquatic vascular plants - aquatic plants containing the conductive vascular tissue, phloem and xylem.
Arachnoid - a. (Gr. *arachme*, spider, cobweb; *eidos*) like a cobweb; covered with or consisting of soft fibers or hairs so entangled as to give a cobwebby appearance.
Arcuate - a. (L. *arcuatus*, pp. of *arcuare*, to arch, bend like a bow, from arcus, a bow) bent or curved in the form of a bow.
Aril - n. (Fr. *arrile*, Sp. *arillo*, L. *arilli*, dried grapes, from *aridus*, dry) an additional covering that forms on some seeds after fertilization, and developing from the stalk of the ovule.
Aristate - a. (L. *arista*, awn) awned; having an awn.
Articulate - a. (L. *articulatus*, jointed, pp. of *articulare*, to join) having joints; jointed; provided with places where separation may take place.
Ascending - v. (Fr. *scandere*, to climb) rising or curving upward.
Asepalous - a. (Gr. *a*, without; L. *pelatum*, petal) without sepals.
Asexual reproduction - Any form of reproduction that does not require the union of male and female reproductive material.
Attenuate - a. (L. *attenuare*, to thin) gradually narrowed to a long point at apex or base.
Auricle - n. (L. *auricle*, small ear) any ear-like lobed appendages.
Aut- or **auto- -** comb. form. (Gr. from *autos*) a combining form meaning self.
Autogamous - adj., relating to, or reproducing by autogamy.
Autogamy - n. (*aut-* + *-gamy*, Gr. *-gamia*, fr, *gamos*, marriage) self-fertilization, pollination of a flower by its own pollen.
Auxins - growth promoting hormones that cause cell elongation, and are responsible for many developmental responses including phototropism.
Awn - n. (Icel. *ogen*, chaff) a stiff, bristlelike appendage, usually at the end of a structure.
Axil - n. (L. *axilla*, armpit) the angle found between any two organs or structures. The junction of the leaf or petiole and the stem.
Axillary - a. (L. *axilla*, armpit) in an axil, growing in an axil, as buds. Arising from the above junction.
Axillary bud - A bud, capable of developing into a lateral shoot, present in the angle between the stem and a leaf.
Ballast - A transformer which changes the voltage from your house outlet to the voltage needed to power different types of lighting.
Barbel - Whisker-like growths around the mouth, used for finding food and communication; a sensory organ.
Barbellate - a. (L. *barba*, beard) provided, usually laterally, with fine, short points or barbs.
Bark - n. (ME. *barke*; AS. *bare*, bark or rind) the outermost covering of trees and some plants. This is composed of the cuticle or epidermis, the outer bark or cortex, and the inner bark or fiber.
Bases - Compounds that make water Alkaline. If water contains more acids than bases it's acidic. If it has more bases than acids it's alkaline.

Bay - n. (Fr. *baia*; LL. *baia*, bay) a part of a sea or lake indenting the shore line; the word is often applied to very large tracts of water around which the land forms a curve, as Hudson's Bay.
Bayou - n. (Fr. *boyau*, a gut, long narrow passage) a marshy inlet or outlet of a lake, river, etc.; also a backwater.
Berry - n. (AS. *berie*, berry) any fleshy simple fruit with one or more seeds and a skin, as a tomato, cranberry, banana, grape, etc.; a several-sided indehiscent fruit with a fleshy pericarp and without a stony layer surrounding the seeds.
Biennial - a. (L. *biennialis*, from *biennis*; *bis*, twice, and *annus*, year) a plant requiring two years in which to complete its life cycle, the first year growing only vegetatively, the second flowering, fruiting, then dying.
Bifid - a. (L. *bifudus*, forked; from *bis*, twice and *findere*, to cleave, divide) forked; divided by a cleft.
Bilabiate - adj., having two lips, as a bilabiate corolla of a flower.
Bilateral - a. (L. *bilateralis*; *bi*, two, and *latus*, a side) having two sides.
Bilaterally symmetrical - said of corolla or calyx (or flower) when divisible into equal halves in one plane only; zygomorphic.
Bilocular - adj., divided into two cells or compartments.
Bio-balls - A filter media used for the colonization of bacteria.
Biogenic decalcification - When there is a carbon dioxide deficiency in the water, plants can derive CO_2 from the hardening constituents of the carbonate hardness. First they split the hydrogen carbonates into CO_2 and carbonates. This causes the pH to rise about one step and the largely insoluble carbonates precipitate and form rough deposits on the leaves and substrate. Some plants such as Vallisneria can even destroy the carbonates and obtain CO_2 from them. This raises the pH again by another step. Biogenic decalcification thus causes the water to be 10 to 100 times more alkaline than it was previously. In the dark, the process reverses and the pH drops considerably.
Biomass - n. (Gr. *bios*, life; *massein*, to squeeze) weight of all living material in a unit area at an instantaneous time. May be expressed as g/m^2, mt/ha, or other similar expressions.
Biotope - Natural environment of an organism.
Bipinnate -Leaf formed of several leaflets set on either side of the petiole.
Bisexual - a. (L. *bis*, twice; *sexus*, sex) having both female and male reproductive organs present and functional in the same flower; hermaphrodite; amphisporangiate; said of a plant having all bisexual flowers.
Black Water - Water that has a dark cola-like color caused by Humic acids, it has a very low pH and is very soft, common in the Amazon river basin.
Blade - n. (AS. *blaed*, leaf) the leaf of a plant, especially grass; the flat or expanded portion of a leaf; lamina.
Bloom - n. (ME. *blome*, a blossom) a blossom; the flower of a plant; an expanded bud; the opening of flowers in general, leaves, flowers, or fruits.
Blossom - n. (ME. *blossome*, a flower) a flower or bloom, esp. of a fruit bearing plant. A state or time of flowering, literally, and figuratively.
Bog - n. (Ir. *bogach*, a bog, from Gael. *bog*, soft moist) a quagmire covered with grass or other plants; wet, spongy ground; a small marsh; plant community on wet, very acid peat.
Bottomland - n., lowlands along streams and rivers, usually on alluvial floodplains that are periodically flooded.
Brackish - a. mixed with salt; briny.

Bract - n. (L. *bractea*, a thin metal plate) a modified leaf, growing at the base or on the stalk of a flower. It usually differs from other leaves in shape or color. Specialized scale-like leaf found at the base of a flower.
Bracteolate - adj., furnished with bracteoles.
Bracteole - n. (NL. *bracteola*, from L. a thin gold leaf) a small bract; especially one on a floral axis. pl. bracteoles.
Branch - n. (LL. *branca*, paw) a natural division of a plant stem.
Branchlet - n., a small, usually terminal, branch.
Breeding tank - An aquarium set up for the breeding of fish.
Bristle - n. (AS. *bristl*, *byrst*, a bristle) stiff, strong but slender hair or trichome.
Bud - n. (ME. *budde*; AS. *budda*, beetle) a small swelling or projection on a plant, from which a shoot, cluster of leaves, or flowers develops; a rudimentary, undeveloped shoot, leaf, or flower; gemma.
Buffer - A substance added to the water to help maintain the pH value.
Bulb - n. (Fr. *bulbe*; L. *bulbus*; Gr. *bolbos*, a bulbous root) a specialized underground bud that sends down roots and consists of a very short stem covered with leafy scales or layers which store water and nutrients, the whole enclosing next year's bud. Tightly packed fleshy leaves used as a storage organ. Onions and tulips both have bulbs.
Bullate - Blistered, bubbled or puckered in appearance.
Caducous - a. (L. *caducus*, falling, from *cadere*, to fall) said of a plant part, such as a sepal, petal, or leaf, that falls off quickly or early.
Calcium - A necessary element used by salt water corals and other organisms for their calcium carbonate skeleton or shell.
Callus - n. (L. *callus*, *callum*, hard skin) a hard protuberance or callosity; new tissue covering a wound.
Calyx - n (Gr. *kalyx*, a calyx, cup) the outer covering of a flower external to the corolla, which it encloses, consisting of a whorl of leaves, or sepals, usually of a green color and less delicate in texture than the corolla.
Calyx tube - tube formed by wholly or partially fused sepals. Not the floral tube of an epigynous or perigynous flower.
Cambium - n. (L. *cambiare*, to exchange, more at change) the layer of tissue between the bark and wood in woody plants, from which new wood and bark develops.
Campanulate - a. (Dim. of LL. *campana*, a bell) bell-shaped, usually applied to calyx and corolla.
Cancellate - a. (L. *cancellatus*, pp., of *cancellare*, to make like a lattice) latticed, or resembling a latticed construction, usually said of a surface such as that of an achene or seed.
Capillary - a. (L. *capillaris*, from *capillus*, hair, from *caput*, head) resembling hair in the manner of growth; very slender, threadlike.
Capitate - a. (L. *caput*, head) enlarged or swollen at tip, gathered into a mass at apex, as compound stigma; a knoblike stigma terminating a style.
Capitulum - n. (L. *capitulum*, small head) an inflorescence forming a head of sessile flowers or florets crowned together on a receptacle and usually surrounded by an involucre.
Capsule - n. (L. *capsula*, a little chest) a case, pod, or fruit, containing seeds, spores, or carpels; it usually bursts when ripe.
Carbonate Hardness - The part of the total hardness that is formed by the ions of carbonates(Co3) and hydrogen carbonate(HCo3). It is symbolized by dCH. It is important to know the dCH of your water, as it affects both the pH and Carbon Dioxide amounts in your water. It is also commonly called "buffering capability". A dCH of 4 to 8 is fine for most fish.

Carinate - a. (L. *carinatus*, from *carina*, a keel) shaped like the keel of a ship; having a longitudinal prominence on the back, like a keel; applied to a calyx, corolla or leaf.
Carpel - n. (Gr. *karpos*, fruit) a simple pistil, regarded as a modified leaf; also, any of the two or more carpels that unite to form a compound pistil; the unit of structure of the female portion of a flower.
Carpels - Female sex organs. They contain the Ovules which become seeds when mature.
Carpophore - n. (Gr. *karpophorus*, bearing fruit; *karpos*, fruit, and *pherein*, to bear) generally the organ that supports the carpels; specifically, a very much elongated axis to which the carpels are attached.
Caryopsis - n. (Gr. *karyon*, a nut, and *opsis*, an appearance) a small one-seeded, dry, indehiscent fruit, in which the seed adheres to the thin pericarp, so that the fruit and seed are incorporated into one body, as in wheat and other kinds of grain.
Castanea - n. (L., a chestnut, from Gr. *kastanon*) a genus of trees typified by the common chestnut.
Castaneous - a., relating to or having the color of a chestnut.
Cataphyll - n. (L. from *cata*, and *-phyll*) any rudimentary leaf, as a bud scale, preceding the true foliage leaves.
Cataphyllary leaves - rudimentary or scale-like leaves which act as a covering of buds.
Cation Exchange Capacity (CEC) - Quantifies the ability of media to provide a nutrient reserve for plant uptake. It is the sum of exchangeable cations, or positively charged ions, that media can adsorb per unit weight or volume. It is usually measured in milligram equivalents per 100 g or 100 cm^3 (meq/100 g or meq/100 cm^3, respectively). A high CEC value characterizes media with a high nutrient-holding capacity that can retain nutrients for plant uptake between applications of fertilizer. Media characterized by a high CEC retains nutrients from leaching. In addition, a high CEC provides a buffer from abrupt fluctuations in media salinity and pH. Important cations in the cation exchange complex in order of adsorption strength include calcium (Ca2+) > magnesium (Mg2+) > potassium (K+) > ammonium (NH4+), and sodium (Na+). Micronutrients which also are adsorbed to media particles include iron (Fe2+ and Fe3+), manganese (Mn2+), zinc (Zn2+), and copper (Cu2+). The cations bind loosely to negatively charged sites on media particles until they are released into the liquid phase of the media. Once they are released into the media solution, cations are absorbed by plant roots or exchanged for other cations held on the media particles. **Anion exchange capacity** Some media retains small quantities of anions, (negatively charged ions, in addition to cations). However, anion exchange capacities are usually negligible, allowing anions such as nitrate (NO3-), chloride (Cl-), sulfate (SO4-), and phosphate (H2PO4-) to leach from the media.
Catkin - n. (L. a dim. of *cat*, from its resemblance to a cat's tail) a scaly spike, the flowers of which are unisexual and petalless.
Caudal fin - Single fin at the back of a fish; the tail fin.
Caudex - n. (L. *caudex*, stem of a tree) the base of a perennial plant; the axis or stem of a woody plant, especially of a palm or tree fern.
Caulescent - a. (L. *caulis*, a stem and *-escent*) having a well-developed stem above ground level.
Cauline - a. (L. *caulis*, stalk or stem) stem.
Cellulose - n. (Fr. from L. *cellula*, dim. of *cella*, a small room) the chief substance composing the cell walls or woody part of plants; a carbohydrate of unknown molecular structure but having the composition represented by the empirical formula $(C_6H_{10}O_5)_x$.
Centrum - n. (L. from Gr. *kentron*, center) central portion.
Cespitose - a., growing in tufts or clumps; matted.

Chaff - n. (AS. *ceaf*, chaff) dry scales or bracts, as those on the receptacle subtending the flowers in the heads of certain Compositae.
Channeled - having a deep longitudinal groove.
Chartaceous - a. (L. *chartaceus*, from *charta*, a leaf of paper) having the texture of thin but stiff paper.
Chasmogamy - n. (Gr. *chasma*, an opening, chasm, and *gamos*, marriage) the opening of the perianth of a flower for the purpose of fertilization; contrast with cleistogamous.
Chelators - Synthetic organic acids that bind with various trace elements to keep them available in a form that is usable by the plants.
Chlorophyll - The pigment that makes plants green. One of the pigments necessary for photosynthesis.
Chlorophyll Absorption - Process of Photosynthesis, occurs between 420-550 nm. and at 670 nm. Values for different type bulbs.
Chlorosis - Loss of chlorophyll, often a sign of insufficient amounts of iron. n. (Gr. *chloros*, pallid) An abnormal condition characterized by absence of green pigments in plants.
Choripetalous - a. (Gr. *choris*, apart, and *petalon*, leaf) polypetalous; having unconnected or separate petals.
Ciliata - a. (L. *cilium*, eyelid) with marginal hairs that form a fringe.
Circumscissile - a. (L. *circum*, around; *scindere*, to cut) opening splitting by a transverse fissure around the circumference, leaving an upper and lower half; said of certain seed pods or capsules.
Clavata - a. (L. *clava*, a club) club-shaped; having the form of a club; growing gradually thicker toward the top, as certain parts of a plant.
Claw - n. (AS. *clawu*, a claw, hoof) the narrowed, stalk-like base of some sepals or petals.
Cleft - a. (AS. *cleofan*, to cut) divided halfway down to the midrib or further, or generally, any deep lobe or cut.
Cleistogamy - n. (Gr. *kleistos*, closed; gamos, marriage) the condition of having flowers which never open and self-pollination occurs; the flowers are often small and inconspicuous.
Clone - n. (Gr. *klon*, a twig) a group of plants, all of whose members are directly descended from a single individual.
Coagulant - A chemical compound used in water clarifiers. It causes fine particles to stick together to be more easily removed by the filter.
Coherent - a. (L. *cohaerere*, to stick together) having parts united.
Collar - n. (L. *collare*, a band or chain for the neck) region of junction between blade and leaf sheath of grasses.
Collenchyma - n. (L. from Gr. *killa*, glue, and *enchyma*, an infusion) living, supportive tissue with chloroplasts generally just beneath the surface consisting or more or less elongated cells usually thickened unevenly in a manner somewhat variable in different groups of plants.
Colonial - a. (Fr. *colonial*, from L. *colonia*, a colony) usually used to describe cloning by vegetative reproduction, the seemingly separate plants having arisen from rhizomes, stolons, or roots of a single or of neighboring "parent" plants.
Colony - n., a stand, group, or population of neighboring plants of one species, the origin having been colonial, from seeds, or both.
Colpate - adj. (Gr. *kolpos* + *E-ate*, of pollen grains) having longitudinal germinal furrows in the exine.

Coma - n. (L. *coma*; Gr. *kome*, hair) a tuft of soft hairs, as at the apices or bases of seeds; a bunch of branches; a terminal cluster of bracts on a flowering stem, as in pineapples.
Commissure - n. (L. *commissura*, a joining together) a place of joining or meeting, as where one carpel joins another in the Umbelliferae.
Communities - Different species of fish kept in the same aquarium.
Comose - a. (L. *comosus*, hairy, from *coma*, hair) having a tuft of hair.
Competition - n. (L. *competitio*, an agreement, rivalry) involves the removal or reduction of some factor from the environment by a plant or group of plants that is sharing the same habitat. Competition can be by an individual or groups of plants of the same or different species. Factors that may be reduced include water, minerals, food, and light.
Compound leaf - A leaf that is divided into several distinct leaflets.
Concretion - n. (L. *concretion*, *concretio*, to grow together) the act or process of making or becoming solid.
Connate - adj. (LL. *connatus*, past part) congenitally united.
Connivent - a. (L. *connivere*, to close the eyes) approximate but not organically united; converging; arching over so as to meet.
Contraction - The shedding of the leaves at the onset of the dormant period.
Convexity - Having the property of curving outward, like the outside of a ball.
Convolute - a. (L. *cum*, together; *volvere*, to wind) said of parts rolled or twisted together when in an undeveloped stage, as in some corollas in the bud stage.
Cordate - a. (L. *cor*, *cordis*, a heart) with a sinus and rounded lobes at the base, the overall outline usually ovate; often restricted to the base rather than to the outline of the entire organ; heart-shaped.
Coriaceous - a. (L. *coriaceus*, from *corium*, leather) leathery; tough.
Corm - n. (L. *cormus*; Gr. *kormus*, the trunk of a tree with the boughs lopped off) an enlarged solid subterranean stem, often rounded in shape but of no distinct characteristic shape or size in some species, filled with nutrients, composed of two or more internodes and covered externally by a few thin membranous scales or cataphyllary leaves.
Cormophyta - n. (Gr. *kormus*, the trunk of a tree with the boughs lopped off; *phyton*, plant) in older classifications, a division comprising all plants that have a stem and root.
Cormophyte - n., a plant of the division Cormophyta.
Corolla - n. (L. *corolla*, a little crown) the inner, usually colored or otherwise differentiated, whorl or whorls of the perianth; the petals of a flower as a whole.
Corymb - n. (Gr. *korys*, a helmet) a racemose type of inflorescence in which the lower pedicels are successively elongated, forming a more or less flat-topped inflorescence, the outer flowers opening before the inner.
Cosmopolitan - Found worldwide.
Cotyledon - n. (Gr. *kotyle*, a hollow or cavity) the first leaf or leaves of a seed plant, found in the embryo of the seed which may form the first photosynthetic leaves or may remain below ground.
Creek - n. (ME. *creke*, *crike*, from ON. *-kriki*, bend, concavity; akin to ON. *krikr*, bend, bay) a natural stream of water normally smaller than, and often tributary to, a river.
Crenate - a. (L. *crena*, a notch) having a notched, indented, or scalloped edge, as certain leaves.
Crenate - Edged with rounded teeth.
CRI; color rendering index **-** A number used for rating light bulbs on a scale up to 100, where 100 is equal to sunlight.
Crispate - With wave margins.

Crown - n. (L. *corona*, a crown, wreath) that part of a stem at or just below the surface of the ground; an inner appendage of a petal or the throat of a corolla; an appendage or extrusion standing between the corolla and stamens, or on the corolla; an outgrowth of the staminal part or circle as in milkweeds.
Crushed coral - A Calcareous substrate material with pH buffering abilities, for marine aquaria.
Culm - n. (L. *culmus*, a stalk, stem) the stalk or stem for such plants as grasses and sedges, usually jointed and hollow.
Cultivar - A man-made (cultivated) variety.
Cuneate - a (L. *cuneatus*, wedge-shaped, from *cuneus*, a wedge) narrowly triangular with the acute angle toward the base; wedge-shaped; tapering toward the point of attachment.
Cusp - n. (L. *cuspis*, a point) rigid, sharp point, especially on a leaf.
Cuspidate - a. (L. *cuspidare*, to make pointed) tipped with a short, rigid point.
Cuticle - n. (L. *cutis*, skin) a continuous layer of fatty substances covering over the outer surfaces of the epidermis of plants; it contains cutin and protects against water and gases. The thin skin of the plant. This is thicker and waxy to maintain moisture in emersed growth.
Cutin - n., a waxy substance which, together with cellulose, forms the outer layer of the skin of many plants.
Cutting - A fragment of plant material that is capable of growing to become another complete, individual plant.
Cuttings - Detached parts of stem plants: they take root after planting and become new plants.
Cyathium - n. (Gr. *kyathos*, cup) a type of inflorescence characteristic of some members of Euphorbiaceae; consisting of a cuplike involucre bearing unisexual flowers; staminate on its inner face, pistillate from the base.
Cyme - n. (Gr. *kyein*, to swell) a cluster of flowers in which each main and secondary stem bears a single flower, the bud on the main stem blooming first; determinate inflorescence in which each growing point ends in a flower.
Cymose - a., bearing a cyme or cymes.
Cystolith - n. (Gr. *kystis*, bladder; *lithos*, stone) a mass of calcium carbonate concretion, occasionally silica, formed on ingrowths of modified epidermal cell walls in some plants, esp. of the Acanthaceae family.
Day neutral plants - plants that flower regardless of day length.
Deciduous - a. (L. *deciduus*, that which falls down) falling after completion of the normal function.
Decimeter - (dm), 3.973 inches, 10 cm, or 0.1 m.
Decumbent - a. (L. *decumbere*, to lie down) trailing on the ground and rising at the tip, as some stems.
Decurrent - a. (L. *decurrere*, to run down) extending downward, applied usually to leaves in which the blade is apparently prolonged downward as two wings along the petiole or along the stem.
Decussate - Opposite pairs of shoots set at right angles to the pairs above and below.
Dehiscence - n. (L. *dehiscere*, to gape) opening and shedding contents; said of stamens and fruits.
Dehisces - vt., to burst or split open, as the seed capsules of plants.
Deltoid - a. (Gr. *delta*, and *eidos*, form) shaped like the Greek letter delta; triangular in outline.
Denitrification - Breakdown of nitrates by anaerobic bacteria into other forms.

Dentate - a. (L. *dens*, a tooth) toothed, with large saw-like teeth on the margin pointing outward, not forward.
Denticle - n. (L. *denticulus*, little tooth) a small tooth or toothlike projecting point.
Denticulate - a., having small teeth; finely dentate. Serrated, edged with small teeth.
Detritus - Organic waste matter that collects on the bottom of fish tanks.
Diadelphous - a. (from *di*-, twice, and Gr. *adelphos*, brother; *-ous*) in two sets as applied to stamens when in two, usually unequal, sets.
Dichotomous - a. (Gr. *dichotous*, a cutting in two) having or consisting of a pair or pairs; paired. Dividing into two equal branches.
Digitate - a. (L. *digitus*, finger) having fingerlike divisions, as some leaves.
Dimorphic - a. (Gr. *dimorphos*, having two forms) having two forms.
Dioecious - a. (Gr. *di*, two; *oikos*, house) said of a kind of plant having unisexual flowers, the male and female flowers on different individual plants.
Dioecious - Having male or female flowers on separate plants.
Diploid - a. (Gr. *diploos*, double; *eidos*, form) having twice the number of chromosomes normally occurring in a germ cell.
Disc flowers - the radically symmetrical flowers of the head in Compositae, as distinguished from the ligulate ray flowers.
Discoid - a. (Gr. *diskos*, a disk) having the form of a disk; discoid flower; a compound flower not radiated, but with tubular florets.
Distal - a. (L. *distare*, to stand apart) farthest away from the point of attachment or origin.
Distichous - a. (Gr. *distichos*, having two rows) two-ranked; in the case of plants with alternate leaves, the arrangement is such that 1st is directly below the 3rd.
Distichous - Leaves arranged in two rows on either side of the stem.
Divaricate - vt. (L. *divaricare*, to spread apart) to branch or spread widely apart.
Divergent - a. (L. *divergere*, to bend away) separated from one another, having tips further apart than the bases
Diverticulate - a. (L. *divertere*, to turn aside) having short offshoots approximately at right angles to axis.
Divided - a. (L. *dividere*, to divide) referring to the blade of an appendage when it is cut into distinct divisions to, or almost to, the midvein.
Division - A method of propagation in which the rhizome or vegetative cone is cut into pieces, each of which is capable of becoming a complete new plant. Division of the vegetative point of Rosette plants into two or more parts for propagation.
DKH - Abbreviation for Degrees of Carbonate Hardness.
Dolomite - A limestone gravel with a small pH buffering ability.
Dormant period - Interruption of growth in an effort to adjust to seasonal periods of stress.
Dorsal - a. (L. *dorsum*, the back) pertaining to the back; the surface turned away from the axis.
Dorsal fin - Single fin mounted on top of the fish. Some species have two, one behind the other.
Down - n. (ME. *down*, *downe*, down; probably of Scandinavian origin) fine, soft feathers; soft, fine hair.
Downy - a., covered with short, fine hairs.
Drupe - n. (Gr. *dryppa*, an overripe olive) a fleshy or pulpy fruit with the inner portion of the pericarp hard or stony and enclosing the seed; usually 1-locular and 1-seeded, sometimes more than 1-locular and more than 1-seeded.
Echinate - a. (L. *echinus*, a hedgehog) set with prickles; prickly, like a hedgehog; having sharp points.

Ecology - n. (Gr. *oikos*, house; and *-logy* Gr. *-logia*, from *legein*, to speak) branch of science concerned with the interrelationships of organisms and their environments esp. as manifested by natural cycles and rhythms, community development and structure, interaction between different kinds of organisms, geographic distributions and population alteration.
Edaphic - a., relating to, or determined by, conditions of the soil.
Elliptic - a. (Gr. *elleipsis*, a falling short, defect, ellipse) an outline that is oval, narrowed to rounded at the ends and widest at about the middle (as the outline of a football); ellipsoid, a solid with an elliptical outline.
Emarginate - vt. (L. *emarginare*, to deprive of the edge) said of leaves, sepals, or petals, and other structures that are notched at the apex.
Emerge - vt. (L. *emergere*, to rise up, rise out) to rise out of a fluid or other covering.
Emergent - n., (ME. Fr. L. *emergent-*, emergens, pres. part. of *emergere*, to emerge - more at emerge) any of various plants (as a cattail) rooted in shallow water and having most of the vegetative growth above the water.
Emersed - Grown so that the roots and bottom portion of the plant are underwater, and the rest of the plant grows above the water. adj., Standing out of or rising above a surface as an aquatic plant with flower stalk emersed.
Emersed plants - plants growing with their roots and a portion of the shoot below the water and the remainder of the shoot above the surface of the water.
Enation - n. (L. *enasci*, to spring up) an abnormal growth of an organ or of an excresence upon any part of a plant.
Endcap - A water resistant socket for fluorescent lamps.
Endemic - a. (Gr. *endemos*, native, belonging to a people) a plant that is native to a particular country or region; not introduced or naturalized. A species found only in one specific location.
Endocarp - n. (Gr. *endo*, within; *karpos*, fruit) the inter layer of the wall of a matured ovary; when its texture differs from the outer wall, it may be hard and stony, membranous, or fleshy.
Ensiform - adj. (F. *ensiforme*, Fr. L. *ensis* sword + F. *forme*, form) having sharp edges and tapering to a slender point; having a shape suggesting a sword.
Entire - a. (L. *integer*, whole, untouched, undiminished) having a margin devoid of any indentations, teeth, or lobes.
Entomophilous - a. (Gr. *entomon*, insect; *philein*, to love) pollination by insects.
Ephemeral - n. (Gr. *ephemeros*, lasting for a day) referring to an organ living a very short time, usually a day or less; lasting a very short time.
Epigynous - a. (Gr. *epi*, upon; *gyne*, woman) growing upon the top of the ovary or seeming to do so, as petals, sepals, and stamens.
Epigyny - n., the condition of being epigynous.
Epipetalous - a. (Gr. *epi*, upon; *petalon*, leaf) having stamens inserted on petals.
Epiphytic - A plant that grows on another plant but is not parasitic.
Equitant - a. (L. *equitare*, to ride) overlapping; said of leaves whose bases overlap the leaves within or above them, as in the Iris.
Erose - a. (L. *erodere*, to wear away) having small irregular notches in the margin, as if gnawed.
Essential flower parts - the stamen and pistil organs of the flower that are required for pollination.
Estuary - n. (L. *aestuarium*, part of the seacoast over which the tide ebbs and flows, from aestus, the tide) an inlet or arm of the sea; especially the wide mouth of a river, where the tide meets the current. pl. estuaries.

Etiolation - The formation of weak, spindly foliage deficient in Chlorophyll, usually occurs in light of too low intensity.
Eutrophic - a. (Gr. *ew*, well; *trophe*, nourishment) the gradual increase in nutrients in a body of water. Natural eutrophication is a gradual process, but human activities may greatly accelerate the process. Rich in dissolved nutrients, often caused by pollution.
Eutrophication - a., the process of becoming eutrophic.
Even-pinnate - said of compound leaves having an even number of leaflets, this is usually easily determined because there is a pair terminally.
Excrescence - n. (L. *excrescere*, to grow out; *ex*, out; *crescere*, to grow) a normal outgrowth; a disfiguring addition.
Excurrent - a. (L. *excurrere*, to run out, project) projecting beyond the tip, as the midrib of a leaf or bract.
Exfoliate - vt. (L. *ex*, out; *folium*, leaf) peeling off in thin layers, shreds, or plates, as the bark of some trees.
Exine - n. (L. *ex*, out of, out) the outer of two layers forming the wall of certain spores (as pollen grains) - called also exosporium.
Exocarp - n. (Gr. *exo*, without; *karpos*, fruit) the outer layer of the wall of a matured ovary.
Exsert - vt. (L. *exserere*, to stretch out) to put forth; to thrust out; to protrude.
Exserted - a., sticking out; extending beyond (some enclosing part).
Exstipulate - a. (L. *ex*, private; *stipula*, a stalk, stem) having no stem.
Falcate - a. (L. *falx*, a sickle) curved like a sickle.
Family - A term used in the classification of organisms. A family is made up of related Genera.
Farinaceous - a. (L. *farina*, meal) containing flour; starchy; mealy.
Farinose - a., full of meal; mealy; covered with a white, powdery substance.
Fascicle - n. (L. *fasciculus*, small bundle) a small bundle or tuft, as of fibers, leaves, etc.
Fastigiate - a. (L. *fastigare*, to slope up) branches erect and close to stem.
Fen - n. (ME. *fen*, *fenne*; AS. *fen*, *fenn*, a marsh, bog, fen) low land covered wholly or partially with water but producing sedge, coarse grasses, or other aquatic plants; boggy land; a moor or marsh; plant community on alkaline, neutral, or slightly acid peat.
Fenestrated - a. (L. *fenstra*, window) a type of leaf anatomy with small perforation or transparent spots. Confined to a few tropical monocotyledons which grow on the island of Madagascar.
Filament - n. (L. *filum*, thread) the stalk bearing the anther.
Filiform - a. (L. *filum*, thread; *forma*, shape) thread-like, long and very slender. Thread like.
Filtration - Method of cleaning aquarium water. There are 3 basic types: "Mechanical" removes particulate material. “Chemical" is removal of dissolved substances by passing through a type of media, like carbon. "Biological" is the process of changing from a harmful substance to a less harmful one, by bacteria.
Fimbriate - n. (L. *fimbriatus*, fringed) cut into regular segments and appearing fringed at the margins.
Fistula - n. (L. *fistula*, pipe) pathological or artificial pipe-like opening; water-conducting vessel - alt. trachea.
Fistulose - a. same as fistulous.
Fistulous - a, having the form or nature of a fistula.
Flabellate - a. (L. *flabellare*, to fan) fan-shaped.
Flaccid - a. (L. *flaccidus*, flabby) weak, limp, soft, or flabby; leaves that do not have enough water and are about to wilt or are wilting.

Floccose - a. (L. *floccus*, a lock of wool) said of pubescence which gives the impression of irregular tufts of cotton or wool.
Florescence - n. (L. *florescence*, to begin to flower) bursting into bloom, alt. anthesis.
Floret - n. (L. *flos*, flower) one of the small individual flowers of a crowded inflorescence such as capitulum; flower with lemma and palea, of grasses; alt. floscule.
Floricane - n., the stem at flowering and fruiting stage (of a bramble, Rubus).
Floscule - n. (L. *flosculus*, little flower) a small flower; a floret.
Flower - n. (ME, *flowre*, *flour*, *flur*; OFr., *flor*, *flur*, *flour*, from L. *flos*, *floris*, a flower) the part of a plant containing or consisting of the organs of reproduction, either together in a monoclinous flower or separate in male and female flowers.
Foliaceous - a. (L. *folium*, leaf) having the form or texture of a foliage leaf; thin and leaf-like; bearing leaves.
Follicle - n. (L. *folliculus*, small sac) a dry dehiscent fruit formed of one carpel, and dehiscing along one side.
Fresh weight - same as wet weight. Generally not a useful measurement for aquatic plants.
Frond - n. (L. *frons*, a leafy branch) a leaf, especially of fern or palm; a leaf-like expansion.
Frond - The "leaf" of a fern.
Fruit - n. (Fr. *fruit*, from L. *fructus*, fruit) the developed ovary of the flower containing ripe seeds, whether fleshy or dry, often used to include other associated parts such as a fleshy receptacle, then called a false fruit.
Frutescent - a. (L. *frutex*, a shrub) shrubby or becoming shrubby.
Funicle - n. (NL. *funiculus*) funiculus.
Funiculus - n. (NL. from L. *funis*, a small rope) the stalk of an ovule. pl. funiculi.
Fusiform - a. (L. *fusus*, a spindle; *forma*, form) shaped like a spindle; thick, tapering at both ends.
Gametophyte - n. (Gr. *gamete*, a wife; *phyton*, plant) the gamete-forming haploid phase in the alternation of plant generations.
Gamopetalous - a. (Gr. *gamos*, marriage; *phyllon*, a leaf) having the petals united so as to form a tubelike corolla. Same as sympetalous.
Gamosepalous - a. (Gr. *gamos*, marriage; *sepalous*) having the sepals united.
Gemma - n. (L. *gemma*, a swelling, bud, gem) a bud or outgrowth of a plant which develops into a new organism. A leaf bud rather than a flower bud.
Gemmates - a. (L. *gemmare*, to put forth buds) buds or outgrowths of a plant which develop into a new individual.
Gemmiparous - a. (L. *gemma*, a bud; *parere*, to bear) to produce gemmates.
General or Total hardness - the sum of carbonate hardness and non-carbonate hardness. Usually expressed in degrees of dH.
Geniculate - a. (L. *geniculatus*, having knee joints, joints) bent like a knee; bent abruptly at the nodes.
Genotype - n. (Gr. *genos*, race; type) the genetic constitution of an individual.
Genus - n. (L. *genus*, race) a taxonomic group consisting of closely related species, genera being grouped into families; plural - genera; a. - generic.
Geophyte - n. (Gr. *ge*, earth; *phyton*, plant) plants with an underground dormant part such as a tuber, bulb, rhizome, etc. to help the plant survive adverse conditions.
Gibberellins - n. (*Gibberella*, a fungal genus) growth hormones that accelerate shoot growth. First discovered in the fungus *Gibberella fujikuroi*, and later in other plants.
Gibbous - a. (L. *gibbus*, hump) a distended, rounded swelling on one side, as on a calyx or corolla tube or segment.
Glabrate - a. (L. *glaber*, smooth) becoming glabrous with age.

Glabrous - a., with a smooth, even surface; without hairs.
Glade - n. (prob. Scand. *golead*, a lighting, illumination, fr. *goleu*, light, clear, AS. *glaed*, bright) open space surrounded by woods or a forest; a marshy and usually low-lying area; a periodically inundated grassy marsh often running between adjacent slopes; a marshy area bounding or forming the headwaters of a stream.
Gland - n. (L. *glands*, acorn) a secreting part or appendage.
Glandular - a. (L. *glandula*, small acorn) having or bearing secreting organs, glands, or trichomes.
Glandular-pubescent - hairs or trichomes capitate and secretory.
Glaucous - a. (L. *glaucus*, sea-green) bluish green; covered with a pale green bloom.
Globose - a. (L. *globosus*, rounded as a ball) rounded; almost spherical; globular.
Glomerate - vt. (L. *glomus*, a ball of yarn) to gather or wind into a ball; growing, collected or arranged in a rounded mass, as glands, flowers, etc.; clustered.
Glomerule - n., a condensed cyme of almost sessile flowers; a compact cluster as of spores.
Glume - n. (L. *gluma*, husk) a chaffy or membranous bract, a bract at the base of a grass inflorescence or spikelet.
Glutinous - a. (L. *gluten*, glue) having a sticky, moist surface; a gluey or sticky exudation.
Guttation - n. (L. *gutta*, drop) formation of drops of water on plants from moisture in air; the process of water being exuded from hydathodes at the enlarged terminations of veins around the margins of the leaves.
Gymnospermae - n. (Gr. *gymnos*, uncovered, naked; *sperma*, seed) an important division of the plant kingdom, being woody plants with alternation of generations, having the gametophyte retained on the sporophyte and seeds produced on the surface of the sporophylls and not enclosed in an ovary.
Gynaecium - n. (Gr. *gynaikeie*, woman's part of a house) the female organs of the flower, consisting of one or more carpels forming one or several ovaries with their stigmas and styles.
Gynecandrous - a., having staminate and pistillate flowers in the same spike or spikelet, the latter above the former.
Gynoecium - n. (Gr. *gyne*, woman; *oikos*, house) the pistil or pistils of a flower, taken collectively; gynaecium.
Gynophore - n. (Gr. *gyne*, woman; *pherein*, to carry) a stalk supporting the ovary.
Gynostegium - n. (Gr. *gyne*, woman; *stege*, roof) a protective covering for a gynaecium, especially as formed by the union of stamens and style.
Habit - n. (L. *habitus*, condition, appearance, dress) the external appearance or way of growth of a plant, e.g. climbing, erect, bushy, etc.; the tendency of a plant to grow in a certain way.
Habitat - n. (L. *habitare*, to inhabit) the locality or external environment in which a plant lives.
Halophyte - n. (Gr. *hals*, salt; *phyton*, plant) any species capable of tolerating 0.5% or more NaCl.
Haplophyte - n. (Gr. *haploos*, simple; *eidos*, form) having the number of chromosomes characteristic of the gametes for the organism.
Hapteron - n. (Gr. *haptein*, to fasten) holdfast, specialized root-like projections that function to anchor a plant.
Hard water - Water with a high concentration of dissolved salts.
Hastate - a. (L. *hasta*, spear) spear shaped, more or less triangular with the two basal lobes divergent. With two out-turned lobes at the base.

Hemicryptophyte - n. (Gr. *hemi*, half; *kryptos*, hidden; *phyton*, plant) a perennial plant having its overwintering buds located at the soil surface.
Herb - n. (L. *herba*, green crop) any seed plant whose stem withers away to the ground after each season's growth; a seed plant with a green, non-woody stem.
Herbage - n. (Fr. *herbe*, an herb) herbs collectively; the green foliage and juicy stems of herbs.
Herbivore - Plant eater.
Heterophyllous - Having leaves of different shapes on the same plant. a. (Gr. *heteros*, other; *phyllon*, leaf) the presence on a single individual of two or more distinct leaf shapes. These leaves may differ markedly in shape, yet have similar gross anatomical organization.
Heterostylic - Having flowers which differ in the relative length of their styles and stamens, such that any one flower is very rarely, if ever, self pollinated.
Heterozygote - n. (Gr. *heteros*, other; *zygon*, yoke) an organism or cell having two different alleles at corresponding loci on homologous chromosomes.
Hibernaculum - n. (L. *hibernare*, winter residence) a plant organ such as a bud, rhizome, turion, etc. which allows a plant to live through adverse conditions
Hilum - n. (L. *hilum*, a little thing, a trifle) the scar on a seed marking the place where it was attached to the seed stalk.
Hirsute - a. (L. *hirsutus*, bristly) set with bristles; hairy; shaggy.
Hispid - a. (L. *hispidus*, rough) having stiff hairs, spines, or bristles.
Hyaline - a. (Gr. *hyalos*, glass) of thin, membranous, transparent or translucent texture.
Hybrid - n. (L. *hibrida*, cross) any cross-bred plant; heterozygote. The offspring of two parents of different species or varieties.
Hydathodes - n. (Gr. *hydatos*, of water; *hodos*, way) an epidermal structure specialized for secretion, or for exudation, of water.
Hydric - a. (Gr. *hydor*, water) characterized by an abundant supply of water.
Hydrometer - A device used to measure salinity of water.
Hydrophilous pollination - The transference of pollen from the Anthers of the Stamens to the Stigmas on the surface of the water or under water.
Hydrophily - n. (Gr. *hydor*, water; *philein*, to love) water pollination.
Hydrophyte - n. (Gr. *hydor*, water; *phyton*, plant) an aquatic plant living on or in water.
Hydropote - n. (Gr. *hydropotes*, water drinker) a cell or cell group found on the lower epidermis of some species such as *Nymphaea*. These cells are thought to function in the uptake of ions from the water.
Hypanthium - n. (Gr. *hypo*, under; *anthodes*, like flowers) an expansion of the receptacle of a flower that forms a saucer-shaped, cup-shaped, or tubular structure (often simulating a calyx tube) bearing the perianth and stamens at or near its rim; it may be free from or united to the ovary.
Hypertrophy - n. (Gr. *hyper*, above; *trophe*, nourishment) excessive growth due to increase in cell size.
Hypocotyl - The part of the Stem of a seedling below the cotyledons.
Hypogynous - a. (Gr. *hypo*, under; *gyne*, female) inserted below the gynoecium, and not adherent; immediately below oogonium; the ovary thus said to be superior. n. hypogyny.
I.D.- An abbreviation for inside diameter, used when measuring tubing dimensions.
IAA - Indole-acetic acid, a natural growth hormone found in plants.
Ich - A very common parasitic disease characterized by white salt-like specks all over the fish.
Idioblasts - n. (Gr. *idios*, one's own; *blastos*, a bud, offshoot) plant cells containing oil, gum, calcium, or other products, and appearing to help provide mechanical support.

Imbricate - a. (L. *imbricare*, to tile) having parts overlapping each other like roof tiles.
Immersed - a. (L. *in*, into; *mergere*, to dip, plunge) growing under water.
Imperfect flower - a flower containing stamen and pistil organs required for pollination but lacking sepals or petals or both of these organs.
Incised - a. (L. *in*, into; *caedere*, to cut) with sharp angles between the lobes; having deeply cleft margins.
Included - a. (L. *in*, in; *claudere*, to shut, close) not projecting beyond an enclosing part.
Incrassate - vt. (L. *in*, in; *crassus*, thick) becoming thick or thicker, especially toward a tip or margin.
Indehiscent - a (L. *in*, not; *dehiscens*, gaping) fruits which do not open to release seeds, but whole fruit is shed from the plant; not opening to release spores.
Indigenous - a. (L. *in*, within; *gignere*, to bear, produce) native; originating or occurring naturally in the place specified.
Inflorence - Flower cluster.
Inflorescence - n. (L. *inflorescere*, to begin to blossom) a flower or putting forth blossoms; the mode of development and arrangement of flowers on an axis; a flowering branch.
Infructescence - n. (L. *in*, into; *fructus*, fruit) the inflorescence in a fruiting stage; collective fruits.
Inter- - (ME. *enter-*, *inter-*; OFr. *entre-*, *inter-*; L. *inter-* from *inter*, prep. between, among, during) a prefix meaning between, among - as intercellular.
Intercellular - adj. lying between cells, as intercellular space in plant tissue.
Interference - n. (L. *inter*, between; *ferire*, to strike) the overall influence of one plant or groups of plants on another, and encompasses allelopathy or competition, or both of these processes.
Internode - n. (L. *inter*, between; *nodus*, knot) the portion of a stem between nodes. The area between two nodes on a plant stem.
Interspecific competition - competition between species for nutrients, space, light, etc.
Intra- - (L., from *intra*, within, inside) a combining form meaning within, inside of, as intracellular.
Intracellular - adj., being or occurring within a body cell or within the body cells.
Intraspecific competition - a type of competition whereby an individual plant competes with one or more members of the same species for nutrients, space, light, etc.
Invertebrate - An animal with no backbone.
Involucel - n. (L. *involucrum*, covering) a secondary involucre, as the bracts subtending the secondary umbels in the Umbelliferae.
Involucre - n., a group of closely placed bracts that subtend or enclose an inflorescence.
Involute - a. (L. *involutus*, rolled up) leaves having the edges rolled inwards at each side, toward the adaxial side.
Involution - n. (L. *involutus*, rolled up) a rolling inwards of leaves.
Iron - The most important trace element for plants. Iron deficiency causes Chlorosis; a disease that makes the plant leaves Yellow.
Kelvin - A temperature reading used to rate the color of light bulbs. 5500 degrees K is equal to sunlight.
Labiate - a. (L. *labium*, lip) lipped, as in a calyx or corolla.
Lacerate - a. (L. *lacer*, mangled, lacerated) said of a margin torn irregularly.
Laciniate - a. (L. *lacinia*, a hem) cut into narrow, jagged lobes or segments.
Lacunate - a. (L. *lacuna*, cavity) with air spaces or chambers in the midst of tissue.
Lagoon - n. (It. And Sp. *laguna*, fr. L. *lacuna*, a ditch, pool, fr. lacus, lake) a shallow lake or pond, especially one connected with a larger body of water; an area of shallow salt

water separated from the sea by sand dunes; the area of water surrounded by an atoll, or circular coral reef.
Lake - n. (ME. *lake*, *lak*; AS. *lacu*, a lake, pool; L. *lacus*, a hollow, a basin, tub, pool, lake) an inland body of water, usually fresh water, formed by glaciers, river drainage, etc., larger than a pool or pond.
Lamellate - a., made up of thin plates or lamina.
Lamina - n. (L. *lamina*, a thin piece of metal or wood) the expanded blade part of a foliar leaf, petal, etc.
The part of a leaf which is flattened, to a greater or lesser degree; as the Leaf Blade.
Laminae - Broad part of the leaf usually attached to the stalk by the petiole; also called the blade.
Lanate - a. (L. *lana*, wool) wooly, with long intertwined, curled hairs.
Lanceolate - a. (L. *lancea*, a lance) shaped like a lance; broadest toward the base and narrowed to the apex, several times longer than wide.
Lanceolate - Spear shaped.
Lateral line - A line of sensory scales along the sides of fish that enables them to detect vibrations and electrical impulses from other fish.
Laterite - An iron-bearing red soil found in tropical areas. Formed by centuries of heat and rain. Substance used in fresh water plant tanks to supply nutrients, either a powder placed under the gravel or chunks mixed in the gravel bed.
Leaf - n. (ME. *leef* fr. OE. *leaf*, akin to OHG. *loub*, leaf, foliage) a lateral outgrowth from a stem that constitutes part of the foliage of a plant and functions primarily in food manufacture by photosynthesis.
Leaflet - One part of a compound leaf.
Legume - n. (L. *legere*, to gather) a 1-locular fruit, usually dehiscent along two sutures, bearing seeds along the ventral suture; a leguminous plant.
Lemma - n. (Gr. *lemma*, husk) the lower (abaxial), and larger, of two membranous bracts enclosing the flower in grass.
Lenticel - n. (L. *lens*, *lentis*, lentil) corky spots on young bark, arising in relation to epidermal stomates.
Lenticular - a. (L. *lenticula*, a lentil) shaped like a double-convex lens.
Lignify - vt., to convert into wood or woody tissue; to become wood or woody by chemical and physical changes in the cell walls that convert some or all of the constituents into lignin or lignocellulose.
Lignin - n. (L. *lignum*, wood) organic substances which act as binders for the cellulose fibers in wood and certain plants, and adds strength and stiffness to the cell walls. Chemical structure of lignin is composed of a polymer of high carbon content but distinct from the carbonates. Consists of C6,C3 units.
Ligulate - a. (L. *ligula*, little tongue) having or pertaining to ligules.
Ligule - n., hyaline extension of the leaf sheath on the adaxial side of the leaf.
Limb - n. (AS. *lim*, limb) the spreading part of a synsepalous calyx or sympetalous corolla, usually referring only to the calyx or corolla lobes, sometimes to their lips.
Limnology - n., the scientific study of physical, chemical, meteorological, and biological conditions in fresh waters.
Linear - a. (L. *linea*, line) long and slender with parallel or nearly parallel sides. Long, narrow, grass-like or strap-like leaf.
Lip - n. (AS. *lippa*, *lippe*, lip) the upper or lower part of a bilabiate calyx or corolla.
Lobulate - a. (Gr. *lobos*, lobe) divided into small lobes.
Locular - a. (L. *loculus*, a cell, box) having the nature of, or consisting of cells.
Locule - n. (L. *loculus*, a cell, box) a compartment of an anther or an ovary.

Loculicidal - a. (L. *loculus*, a cell, box; *caedere*, to cut) dehiscent dorsally down middle of carpels.
Lodicule - n. (L. *lodicula*, coverlet) a scale at base of an ovary in grasses, supposed to represent part of a perianth.
Loment - n. (L. *lomentum*, bean meal) a fruit of some legumes, contracted between the seeds, the 1-seeded segments separating at fruit maturity.
Long-day plant - a plant that requires more than 12 hours of daylight before flowering will occur.
Lumens - A measurement of light intensity. (1 lumen=10.76 lux).
Lunate - a. (L. *luna*, moon; *-ate*) crescent-shaped.
Lux - The standard for measuring light.
Macronutrients - Nutrients used by plants in relatively large amounts. They are nitrogen (N), phosphorus (P), sulfur (S), calcium (Ca), magnesium (Mg) and potassium (K).
Macrophyte - n. (Gr. *makros*, large; *phyton*, plant) a member of the macroscopic plant life especially of a body of water; large aquatic plant; the term 'aquatic macrophyte' has no taxonomic significance.
Macroscopic - a. (Gr. *makros*, large; *skopein*, to view) items large enough to be observed by the naked eye.
Marcescent - a. (L. *marcescere*, to wither) withering but remaining persistent.
Marsh - n. (ME. *mersh*, meadowland) a tract of wet land principally inhabitated by emergent herbaceous vegetation.
Membranous - a. (L. *membrana*, mem- brane) having a thin, soft, pliable texture.
Mericarp - one of the two carpels that resembles achenes and forms the schizocarp of an umbelliferous plant.
Mesic - a. (Gr. *mesos*, middle) conditioned by temperate moist climate; neither xerix nor hydric; pertaining to conditions of medium moisture supply.
Micronutrients - Nutrients used by plants in small amounts. They are iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), molybdenum (Mo), cobalt (Co), and boron (B).
Microphyllidious - small, leaf-shaped.
Mire - n. - synonymous with any peat-accumulating wetland.
Moniliform - a. (L. *monile*, necklace; *forma*, shape) constricted laterally and appearing beadlike.
Monoclinous - a. (Gr. *monos*, single, alone; *kline*, bed) having both stamens and pistils in the same flower.
Monocotyledons - n. (Gr. *monos*, single; *kotyledon*, cup-shaped hollow) a class of angiosperms having an embryo with only one cotyledon, part of the flower usually in threes, leaves with parallel veins, and scattered vascular bundles.
Monoculture - A large group of a single species of plant.
Monoecious - a. (Gr. *monos*, single; *oikos*, house) a plant having unisexual male and female flowers on the same individual; said of a plant having unisexual flowers.
Monotypic - a. (Gr. *monos*, only; *typos*, type) a plant of only one type.
Moor - n. (ME. *mor*, fr. OE *mor*; akin MD. *moer*, mire, swamp) chiefly British: an extensive area of open rolling infertile land consisting of sand, rock, or peat usually covered with heather, bracken, coarse grass and sphagnum moss; a boggy area of wasteland usually dominated by grasses and sedges growing in a thick layer of peat.
Morphology - n. (G. *morphologie*, fr. Gr. *morph* - (fr. *morphe*, form) + G. *-logie*, -logy, more at form) a branch of biology that deals with the form and structure of animals and plants, a study of the forms, relationships, metamorphoses, and phylogenetic development of organs apart from their functions.
Mucro - n. (L. *mucro*, sharp point) a stiff or sharp point abruptly terminating an organ; a small awn.

Multipinnate - Leaf divided into several sub-groups of leaflets.
Muricate - a. (L. *muricatus*, having sharp points) having a rough surface texture owing to small, sharp projections.
Naturalize - vt. (Fr. *naturel*, natural) to adapt to an environment not native; of foreign origin, but established and reproducing as though native.
Nectar - n. (L. *nectar*, nectar; Gr. *nektar*, the drink of the gods, from base of necros, dead, dead body, and tar-, who overcomes; hence, death overcoming; so named because the drink was held to confer immortality) the sweetish liquid in many flowers used by bees for the making of honey.
Nectary - n. (Gr. *nektar*, nectar) a part of a flower that secretes nectar. pl. nectaries
Neomorphosis - n. (Gr. *neos*, new; *morphosis*, change) regeneration in cases where the new part is unlike anything in the body.
Neoteny - n. (Gr. *neos*, young; *teinein*, to extend, stretch) the retention of juvenile characteristics in the adult individual.
Neotropical - From the tropical areas of the new world (South or Central America).
Neutral flower - said of a sterile flower composed of a perianth without any sexual organs.
Node - n. (L. *nodus*, knob) a knob or joint of a stem from which leaves, roots, shoots, or flowers may arise. A node will contain one or more buds. The point on a plant stem from which the leaves and/or roots appear.
Nodose - a., nodular, knotty.
Nomenclature - n. (L. *nomen*, name; *calare*, to call) the making and giving distinguishing names to all groups of plants.
Nut - n. (ME. *nute*, *note*, fr. OE *hnute*; akin to OHG *nuz*, *hnuz*, nut) a hard-shelled dry fruit or seed having a more or less distinct separatable rind or shell and interior kernel or meat; a dry indehiscent one-seeded fruit with a woody pericarp developing from an inferior syncarpous ovary.
Nutlet - a small nut.
Oblanceolate - a. (L. *ob*, reversely; *lancea*, spear) shaped like a lance point reversed, that is, having the tapering point next to the leafstalk.
Oblique - a. (L. *obliquus*, slanting) slanting; unequal-sided.
Oblong - a. (L. *oblongus*, rather long) elliptical and from two to four times as long as broad.
Obovate - a. (L. *ob*, against; *ovum*, egg) inversely ovate; having the shape of the longitudinal section of an egg, with the broad end at the top, as some leaves.
Obovoid - a. (L. *ob*, against; *ovum*, egg; Gr. *eidos*, shape) inversely ovoid; roughly egg-shaped, with narrow end downwards; said of some fruits.
Obsolete - a. (L. *obsolescere*, to go out of use) rudimentary or not evident; applied to a structure that is almost suppressed; vestigial.
Obtuse - a. (L. *obtusus*, blunt) with blunt or rounded end.
Ocean - n. (ME. *ocean*; L. *oceanus*, fr. Gr. *okeanos*, the ocean) the great body of salt water that covers mores than two thirds of the surface of the earth; any of its five principal geographical divisions, the Atlantic, Pacific, Indian, Arctic, and Antarctic.
Ocrea - n. (L. *acrea*, greave or legging) - a tubelike covering around some stems, especially of plants of the Polygonaceae.
Odd-pinnate - said of compound leaves having an odd number of leaflets, this is usually easily determined because there is a single terminal leaflet.
Offset - Young plant growing along a stolon from the parent plant.
Oligotrophic - Deficient in nutrients needed for plant growth.

Opposite - a. (L. *opponere*, to oppose) said of leaves or bracts occurring two at a node on opposite sides of the stem. Said of flower parts when one part occurs in front of another.
Orbicular - a. (L. *orbis*, circle) round or shield-shaped with petiole attached to center.
Ovary - n. (L. *ovum*, an egg) the enlarged hollow part of a pistil in angiosperms in which ovules are formed.
Ovate - a. (L. *ovum*, an egg) having the shape of a longitudinal section of an egg; egg-shaped and attached by the broader end. Egg-shaped.
Oviparous - a. (L. *ovum*, an egg; *parere*, to produce) egg-laying; producing eggs which hatch after leaving the body of the female; germinating while still attached to the parent plant; for example, mangrove.
Ovoid - a. (L. *ovum*, an egg) egg-shaped.
Ovule - n. (L. *ovum*, an egg) a structure in seed plants which contains the megasporangium (nucellus), megaspore (embryo sac), a food store, and a coat, and develops into a seed after fertilization.
Palea - n. (L. *palea*, chaff) the upper, and usually shorter and thinner, of two membranous bracts enclosing the flower in grasses.
Palmate - a. (L. *palma*, palm) leaves divided into lobes arising from a common center.
Paludal - From a marshy or swampy environment.
Pandurate - a. (L. *pandura*, a bandore) shaped somewhat like a violin, as some leaves.
Panicle - n. (L. *panicula*, a tuft of plants) a branched racemose inflorescence often applied more widely to any branched inflorescence.
Paniculate - a., panicled; arranged or growing in panicles.
Papilla - n. (L. *papilla*, nipple) a glandular hair with one secreting cell above the epidermis level.
Papillose - a. (L. *papilla*, nipple) descriptive of a surface beset with short, blunt, rounded, or cylindrical projections.
Parenchyma - n. (Gr. *para*, besides; *enchyma*, infusion) plant tissue, generally soft and of thin-walled, relatively undifferentiated cells which may vary in structure and function.
Parietal - a. (L. *paries*, wall) when the placenta is attached to the wall of the ovary.
Peat - n. (ME. *pete*, fr. ML. *peta*, perh. of Celt. origin; akin to W. *peth*, thing - more at piece) a piece of turf cut for use as a fuel; a mass of partially carbonized plant tissue formed by partial decomposition in water of various plants and esp. of mosses of the genus Sphagnum, widely found in many parts of the world, varying in consistency from a turf to a slime used as a fertilizer, as stable litter, as a fuel, and for making charcoal.
Pectinate - a. (L. *pecten*, comb) comb-like.
Pedicel - n. (L. *pedicellus*, foot) the stalk of a flower in an inflorescence. The stem of an individual flower.
Peduncle - n. (LL. *pedunculus*, small foot) the stalk of a flower borne singly or the stalk of an inflorescence.
Peltate - a. (Gr. *pelta*, target) shield-shaped; leaves that are shaped like a shield and attached to the stem at the center or by some point distinctly within the margin, and having the petiole inserted into the undersurface of the lamina not far from the center.
Penicullate - a. (L. *penicillus*, a pencil or small brush) having the form of a pencil.
Perennation - n. (L. *perennis*, perennial) survival of a plant for a number of years. To live over from season to season.
Perennial - a. (L. *perennis*, through; *annus*, a year) a plant that grows for 3 or more years and usually flowers each year.
Perfect flower - a flower with both essential and accessory organs.
Perfoliate - a. (L. *per*, through; *folium*, a leaf) said of opposite or whorled leaves or bracts that are united into a collar-like structure around the stem that bears them.

Perianth - n. (Gr. *peri*, around; *anthos*, flower) the outer whorl of floral leaves of a flower, when not clearly divided into calyx and corolla; collectively, the calyx and corolla, or either one if one is absent.
Pericarp - n. (Gr. *peri*, around; *karpos*, fruit) the fruit wall which has developed from the ovary wall; sometimes used for any fruit covering.
Perigynium - n. (Gr. *peri*, around; *gyne*, female) fruit investing utricle of the sedges, Carex.
Perigynous - a. (Gr. *peri*, around; *gyne*, female) growing in a ring around the pistil, as the stamens; having stamens, etc. growing in this way, said of a flower.
Persistent - a. (L. *persistere*, to persist) remaining attached after the normal function has been completed.
Petal - n. (Gr. *petalon*, leaf) any of the component parts, or leaves, of a corolla; the unit of structure of the corolla.
Petaloid - a. (Gr. *petalon*, leaf; *eidos*, form) like a petal.
Petiolate - a. (L. *petiolus*, small foot) growing on, or provided with, a petiole.
Petiole - a. (L. *petiolus*, small foot) the slender stalk or stem of a leaf, also called a leaf stalk. The "stalk" attaching the leaf to the stem.
Phenotype - n. (Gr. *phainein*, to appear; *typos*, image) the characters of an organism due to the interaction of genotype and environment, a group of individuals exhibiting the same phenotypic characters. The detectable expression of the interaction of genotype and environment constituting the visible characters of an organism.
Phenotypic - a., a set of characters arising from reaction to environmental stimulus.
Phloem - n. (Gr. *phloios*, inner bark) the tissue involved in the transport of carbohydrates and food materials in a vascular plant, being composed of sieve elements, parenchyma cells and sometimes also of fibers and sclereids.
Photosynthesis - The conversion of light energy into chemical energy: carbohydrates, (sugar and starch), are produced from carbon dioxide and water through the action of light on the chlorophyll of green plants. Oxygen is released in the process.
Phyllode - n. (Gr. *phyllon*, leaf; *eidos*, form) a winged petiole with flattened surfaces placed laterally to the stem and functioning as a leaf.
Phyllotaxy - n. (L. *phyllo-*, and Gr. *taxis*, arrangement) the arrangement of the leaves on the stem. The three common positions are: alternate, opposite, and verticillate.
Phylogeny - n. (Gr. *phyle*, tribe; E. *genesis*) the racial history or evolutionary development of any plant or animal species.
Pileus - n. (L. *pileus*, cap) umbrella-shaped structure of mushrooms or toadstools.
Pilose - a. (L. *pilosus*, hairy) hairy; pubescence comprised of scattered long, slender, soft hairs.
Pinna - n. (L. *pinna*, feather) a leaflet or a primary division of a compound leaf. pl. pinnas or pinnae.
Pinnate - a. (L. *pinnatus*, feathered) divided in a feathery manner; with lateral processes of a compound leaf, having leaflets on each side of an axis or midrib.
Pinnate - Divided.
Pinnule (also pinule) - n. (NL. *pinnula*, fr. L., small feather, small fin) a secondary pinna, one of the ultimate divisions of a bipinnate or twice-pinnate leaf.
Pistil - n. (L. *pistillum*, pestle) the unit of female function of a flower, may be comprised of a single carpel or two or more carpels united.
Pistillate - n., said of a flower bearing a pistil or pistils but not stamens, may refer also to a plant having only pistillate flowers.
Pith - n. (AS. *pitha*, pith) the soft, spongy tissue, consisting of cellular tissue, in the center of certain plant stems.

Placenta - a. (L. *placenta*, flat cake) the part of the ovary from which the ovules arise. It generally occupies the whole or a portion of an angle of a cell.
Placentation - n., the manner in which the placenta is arranged in the ovary.
Plano-convex - flat on one side and convex on the other.
Plant - n. (L. *planta*, plant) any of a kingdom (Plantae) of living beings typically lacking locomotive movement or obvious sensory organs, generally making its own food, possessing cell walls, and unlimited growth.
Plantlet - n., a little plant. Plantlets that develop asexually from a parent plant: a rooted plantlet forming on a part of the mother plant.
Plicate - a. (L. *plicatus*, to fold) folded into plaits, usually lengthwise; arranged in pleats, as a fan.
Plumiform - Feather shaped.
Plumose - a. (L. *plumosus*, feather) with hairlike branches, feathery.
Pollen - n. (L. *pollen*, *pollis*, fine flour) the male or fertilizing element of seed plants, consisting of fine yellowish powder formed within the anther of the stamen.
Pollinium - n., a mass of coherent pollen characteristic of orchids and milkweeds.
Polygamo-dioecious - polygamous but chiefly dioecious.
Polygamo-monoecious - polygamous but chiefly monoecious.
Polygamous - a. (Gr. *polys*, much or many; *gamos*, marriage) having bisexual, pistillate, and staminate flowers on the same individual plant.
Polymorphic - a. (Gr. *polys*, many; *morphe*, shape) having, assuming, or occurring in various forms, characters, or styles.
Polymorphous - Having multiple shapes.
Polypetalous - a. (Gr. *polys*, many; *petalon*, a petal) with many separate petals.
Pond - n. (form of pound, enclosure) a body of standing water smaller than a lake, often artificially formed.
Pocosin - n. (Algonquian) a bog that has formed in a shallow, undrained depression, the surrounding land being somewhat elevated, the vegetation predominantly evergreen shrubs or small trees. Pocosins vary greatly in size.
Prickle - n. (ME. *prikle*, *prikel*, fr. OE. *prickle*, *pricel*; a kin to MD. *prikel*, prickle) a sharp pointed emergence arising from the epidermis or bark of a plant.
Primary production - the quantity of new organic matter created by photosynthesis.
Procumbent - a. (L. *pro*, forward; *cubare*, to lie down) trailing or lying flat but not rooting.
Production - n. (L. *producere*, to produce) the weight of new organic material formed over a period of time, plus any losses during that time period. Losses may be due to respiration, excretion, secretion, injury, death, or grazing.
Productivity - n., amount of production over a given period of time. Expressed as a rate such as g/m^2 per day, kg/ha per year, etc.
Proliferous - a. (L. *proles*, *prolis*, offspring; *ferre*, to bear) bearing supplementary structures such as buds or flowers, either in an abnormal manner or in a manner that is normal but from adventitious tissue.
Propagulum or **propagule -** n. (L. *propages*, layer of a plant) a runner or sucker used in the asexual propagation of plants. pl. propagula or propagules.
Prostrate - a. (L. *prostratus*, pp. of *prosternere*, to lay flat) growing on the ground, trailing.
Protogyny - n. (Gr. *proteros*, fore; *gyne*, female) development of the female organs before the appearance of the corresponding male products - thus inhibiting self-fertilization.
Pseudolamina - n. (Gr. *pseudes*, false; L. *lamina*, plate) the extended apical portion of a phyllode.

Pseudovivipary - n. (Gr. *pseudes*, false; L. *vivus*, alive; *parere*, to produce) a condition where vegetative propagules replace some or all of the normal sexual flowers in the inflorescence.
Pteridophyte - n. (Gr. *pteris*, fern; *phyton*, plant) a major division of the plant kingdom, having clear alternation of generations with a dominant vascular sporophyte initially dependent upon the gametophyte which is very reduced.
Puberulent - a. (L. *pubes*, adult) covered with fine, short, and nearly imperceptible down; minutely pubescent, the hairs soft, straight, erect, but scarcely visible to the unaided eye.
Pubescent - a. (L. *pubescere*, to become mature) a general term for hairiness; covered with soft hair or down.
Punctate - a. (L. *puntcum*, point) dotted; with depressed dots scattered over the surface.
Pustulate hair - a. (L. *pustulare*, to blister) hair with an enlarged base.
Pyriform - a. (L. *pyrum* or *pirum*, a pear) pear-shaped.
Raceme - A group of flowers similar to a spike, but with each individual flower on its own stem.
Raceme - n. (L. *racemus*, bunch) inflorescence having a common axis and stalked flowers in acropetel succession.
Racemose - a., an inflorescence whose growing points continue to add to the inflorescence and in which there are no terminal flowers, and the branching is monopodial, as racemes, or spikes.
Rachilla - n. (Gr. *rhachis*, spine) the zigzag center upon which the florets are arranged in the spikelet of grasses or in some sedges.
Rachis - n., the central prolongation of the stalk (peduncle), the axis through an inflorescence, or of a leaf stalk (petiole), the axis through a compound leaf.
Radially - a. (L. *radius*, a ray, a rod, a spoke) arranged, or having parts arranged, like rays; developing uniformly around a central axis.
Radially symmetrical - said of a flower or set of flower parts which can be cut through the center into equal and similar parts along two or more planes; actinomorphic.
Ramet - n. (L. *ramus*, branch) an individual member of a clone.
Receptacle - n. (L. *recipere*, to receive) the more or less expanded apex of a floral axis which bears the floral parts.
Remote - a. (L. *remotus*, to remove) separated from one another; separated by intervals or spaces greater than the ordinary.
Reniform - a. (L. *ren*, kidney; *forma*, shape) having the form or shape of a kidney.
Repent - a. (L. *repens*, crawling) said of a stem that is prostrate and rooting at the nodes.
Reticulate - a. (L. *reticulatus*, latticed) like network.
Retinaculum - n. (NL. fr. L. that which holds or binds, band, fr. *retinere*, to hold back, retain) the hook-like funicle of a seed of a plant of the family Acanthaceae; a band or band-like structure that holds an organ in place. pl. retinacula.
Retrorse - a. (L. *retrorsum*, backward) having hairs or other processes turned toward the base.
Retuse - a. (L. *retuses*, blunted) with a shallow, rounded notch at the apex.
Revolute - a. (L. *revolvere*, to roll back) said of margins that are rolled backward (toward the abaxial side).
Rhizomatous tuber - same as a corm.
Rhizome - n. (Gr. *rhiza*, a root) a subterranean horizontal root-like stem sending out leaves and shoots from its upper surface and roots from its lower surface.
Rhombus - n. (Gr. *rhombos*, object that can be turned) an outline like a rhomboid, a parallelogram with equal sides, having two oblique angles and two acute angles.

Root - n. (AS. *wyrt*, root) the part of a plant, usually below the ground, that holds the plant in position, draws water and nutrients from the soil, stores food, and is typically non-green.
Root pressure - pressure in the roots which, when the shoot is cut off, will cause liquid to secrete from the root stump; the mechanisms and tissues involved in this process are not clearly understood.
Root tuber - swollen food-storing roots.
Rootlet - n., a radicel; a little root or small branch of a root.
Rootstock - same as a rhizome.
Roseate - a. (L. *roseus*, rosy) rose-colored; rosy.
Rosette - A plant that rises from a distinct crown. A group of organs, such as leaves, clustered and crowned around a common point of attachment.
Rotate - a. (L. *rota*, wheel) shaped like a wheel; radially spreading in one plane.
Rugose - a. (L. *ruga*, a wrinkle) having or full of wrinkles; corrugated; ridged.
Rugulose - a., same as rugose.
Runcinate - a. (L. *runcina*, a plane) pinnatified, with the lobes convex before and straight behind, pointing backward, like the teeth of a saw, as in the dandelion leaf.
Runner - n. (AS. *rinnan*, to run) a specialized stolon consisting of a prostrate stem rooting at the node and forming a new plant which eventually becomes detached from the parent plant as in a strawberry plant.
Saccate - a. (L. *saccus*, bag) having the form of a sac; pouchlike.
Sagittate - a. (L. *sagitta*, arrow) shaped like the head of an arrow with the basal lobes pointing downward.
Salverform - a. (L. *salvus*, safe; *forma*, shape, figure, image) said of a corolla in which the tube is essentially cylindrical, the lobes abruptly spreading; a gamopetalous corolla.
Sarmentose - adj. (L. *sarmentosus*, fr. sarmentum, twig; plus, *-osus*, *-ose*) producing slender prostrate branches or runners.
Scabrid - a. (L. *scabridus*, rough) slightly roughened.
Scabrous - a. (L. *scabrosus*, rough) with small points or knobs, like a file; scaly, scabby, rough.
Scandent - adj. (L. *scandent-*, *scandens*, pres. part. of *scandere*, to climb - more at scan) climbing plant of a creeping or scandent nature.
Scape - n. (L. *scapus*, the shaft of a pillar, the stalk of a plant) a stem growing from the crown of the root, bearing the blossom without leaves.
Scapose - a. scape-bearing; scapigerous; consisting of a scape.
Scarious - a. (LL. *scariousus*, rough) tough, thin, dry, and semitransparent.
Schizocarp - n. (Gr. *schizein*, to cleave; *karpos*, fruit) a dry fruit, as in the maple, that splits at maturity into two or more one seeded carpels which remain closed.
Sclerenchyma - n. (Gr. *skleros*, hard; *enchyma*, an infusion) tissue of uniformly thick-walled, dead cells in the stem whose principal function is mechanical. The cells are usually grouped into fibers.
Scorpioid - a. (Gr. *skorpois*, scorpion; *eidon*, form) resembling a scorpion; said of a circinnately coiled determinate inflorescence in which the flowers are two-ranked and borne alternately at the right and left.
Secund - a. (L. *secundus*, following) arranged or growing on one side only, as flowers or leaves on a stem.
Seed - n. (AS. *saed*, seed) the part of a flowering plant that contains the embryo and will develop into a new plant if sown; a fertilized and mature ovule.
Sepal - n. (Fr. *sepale*; L. *separatus*, separate; *pelatum*, petal) any of the leaf divisions of the calyx. When a calyx consists of but one part, it is said to be monosepalous; when of two parts, it is said to be disepalous; when of a variable and indefinite number of parts, it

is said to be polysepalous; and when the parts are more or less united, it is said to be gamosepalous.
Septate - n. (L. *septatus*, surrounded by a fence) having or divided by a septum or septa.
Septicidal - a. (L. *septum*, division; *caedere*, to cut or divide) dividing through middle of ovary septa; dehiscing or breaking open at a natural dividing line.
Septum - n. (L. *septum*, a partition) a partition separating two cavities or masses of tissue, as in fruits. pl. septa.
Serrate - a. (L. *serrare*, to saw) notched on edge like a saw; having sharp notches along the edge pointing toward the apex; as a serrate leaf. When a serrate leaf has small serratures upon the large ones, it is said to be double serrate, as in the elm. A serrate-ciliate leaf is one having fine hairs, like eyelashes, on the serratures. A serrate-dentate leaf has the serratures toothed.
Sessile - a. (L. *sedere*, to sit) sitting directly on base without support, stalk, pedicel, or peduncle; attached or stationary as opposed to free living or motile. A leaf that is directly attached to the plant stem with no petiole.
Seta - n. (L. *seta*, bristle) a bristle-like structure.
Setaceous - a. (L. *seta*, a bristle) bristly; set with bristles; consisting or having bristles.
Shaft - Flower-bearing stalk.
Sheath - n. (AS. *sceth*, shell or pod) a protective covering; lower part of leaf enveloping stem or culm.
Shoot - n. (ME. *schoten*, to shoot, dart) a young branch which shoots out from the main stock.
Short-day plant - a plant requiring less than 12 hours of daylight in order for flowering to occur.
Silique - n. (L. *siliqua*, a pod) the long, narrow pod of plants of the mustard family, Cruciferae, with valves which fall away from a frame bearing the seeds.
Sinuate - a. (L. *sinuare*, to bend) having a wavy margin, as some leaves.
Sinus - n. (L. a bent surface, a curve, a fold or hollow, bosom, a bay) the rounded depression between two consecutive lobes. as of a leaf. pl. sinuses, sinus.
Slough - n. (AS. *sloh*, a slough) a wet place of deep mud or mire; a sluggish channel; a swamp, bog, or marsh, especially one that is part of an inlet or backwater.
Spadix - n. (L. *spadix*, a palm branch) a racemose inflorescence with elongated axis, sessile flowers, and an enveloping spathe; a succulent spike; a fleshy spike of flowers, usually enclosed in a spathe.
Spathaceous - a., having a spathe, or having the nature of a spathe.
Spathe - Modified leaf surrounding the flower .
Spathe - n. (Gr. *spathe*, flat blade) a large leaflike part or pair of such enclosing a flower cluster (especially a spadix).
Spatulate - a., shaped like a spatula or spoon, gradually widening distally and with a rounded tip, as some leaves.
Species - n. (L. *species*, particular kind) a group of interbreeding individuals, not interbreeding with another such group, being a taxonomic unit including two names in binomial nomenclature, the generic name and specific epithet, similar and related species being grouped into a genus.
Spermatophyta - n. (Gr. *sperma*, seed; *phyton*, plant) a major division of the plant kingdom, characterized by reproducing by seed and subdivided into the Gymnospermae and Angiospermae.
Spicate - a. (L. *spicatus*, pp. of *spicare*, to furnish with spikes) having the form of a spike.

Spicule - n. (L. *spicula*, a small spike) a small, slender, sharp-pointed piece, usually on a surface; a small spike of flowers.
Spike - n. (L. *spica*, spike, ear of corn) a long flower cluster attached directly to the stalk. A group of flowers arranged closely at the end of a shaft, and attached directly to the shaft.
Spikelet - n., a small spike of a large one; a subdivision of a spike; as the spikelets of grasses.
Spine - n. (ME, *thorn*, spinal column, fr. L. *spinsa*, thorn, spine, spinal column) a stiff sharp-pointed plant process as a modified leaf, leaf part, petiole, or stipule.
Sporangium - The reproductive organ of primitive plants like ferns and mosses.
Spore - n. (Gr. *sporos*, seed) any of various small reproductive bodies, often consisting of a single cell, produced by mosses, ferns, etc. asexually (asexual spore) or by the union of gametes (sexual spores); they are highly resistant and are capable of giving rise to a new adult individual, either immediately or after an interval of dormancy.
Sporophyte - n. (Gr. *sporo*, a seed; *phyton*, plant) the diploid spore-producing phase in plants with alternation of generations.
Spur - n. (AS. *spura*, *spora*, a spur) a slender, tubelike structure formed by an extension of one or more petals or sepals; also refers to a very short branch with closely spaced leaves.
Stalk - n. (probably from Dan. *stilk*; Sw. *stjelk*; Icel. *stilker*, a stalk) the stem or main axis of a plant, which supports the leaves, flowers, and fruit. Any lengthened support on which an organ grows, as the petiole of a leaf or the peduncle of a flower.
Stamen - n. (L. *stare*, to stand) the male reproductive organs in flowers; it is situated immediately within the petals, and is composed, in most cases, of two parts, the filament, and the anther, which is filled with pollen.
Staminate - a., producing or consisting of stamens; flowers with stamens but not pistils.
Staminodium - n. (L. *stamen*, a thread, and Gr. *eidos*, form) a sterile stamen or an organ resembling one.
Standing crop - weight or organic material that can be sampled or harvested at any one time from a given area, but may not necessarily include the entire plant. Usually refers to normal harvesting procedures, unless specified, for the particular plant under consideration.
Stellate - a. (L. *stella*, star) starlike; said of hairs that branch in such a manner as to radiate from a central point.
Stem - n. (AS. *stemm*, tree stem) main axis of a plant typically above the soil surface, having leaves or scales, and a characteristic arrangement of the vascular tissue.
Stem tuber - swollen structures produced by stolons and runners which remain dormant during adverse conditions and later grow into new plants when the conditions become favorable for growth.
Stigma - n. (Gr. *stizein* to prick) the upper tip or part of the pistil of a flower receiving the pollen. It is generally situated at the upper extremity of the style.
Stipe - n. (L. *stipes*, stalk) the stalk-like basal part of an ovary, or of a fruit such as an achene; the stem bearing pileus in mushrooms and toadstools.
Stipel - n., a small secondary stipule at the base of a leaflet.
Stipule - n. (L. *stipula*, a stalk, a straw) one of two foliaceous or membranaceous processes developed at base of a leaf petiole, sometimes in tendril or spine form, sometimes fused.
Stolon - n. (L. *stole*, *stolonis*, a twig, shoot) a stem which grows from a stem above the ground, taking root at the tip, and ultimately developing a new plant.
Stoma - n. (NL. fr. Gr. mouth - more at stomach) one of the minute openings in the epidermis of leaves, stems, and other plant organs through which gaseous interchange

between the atmosphere and the intercellular spaces within these structures occur; the opening together with its associated guard cells and accessory cells. pl. stomata.
Stramineus - a. (L. *stramen*, straw) of or like straw; straw-colored.
Striated - a. (L. *striatus*, grooved) marked by narrow lines or grooves, usually parallel.
Strigose - a. (L. *striga*, a furrow) covered with stiff hairs; ridged; marked by small furrows; surface clothed with stiff, often appressed hairs, these usually pointing in one direction.
Style - n. (Gr. *stylos*, pillar; L. *stylus*, pricker) slender upper part of pistil, supporting stigma.
Stylopodium - n. (Gr. *stylos*, pillar; *pous*, foot) the fleshy support at the base of the style in flowers of the carrot family, Umbelliferae.
Submerge - vt. (L. *submergere*, to dip or plunge under) to sink or plunge beneath the surface of water.
Submersed - Growing completely underwater.
Submersed plants - plants growing with their root, stems, and leaves completely under the surface of the water.
Suborbicular - adj. (L. *sub*, under, below; *orbis*, circle) approximately circular.
Subulate - a. (L. *subula*, an awl) awl-shaped; slender and tapering gradually to a fine point.
Succulent - n. (L. *succus*, juice) juicy; full of juice or sap.
Suffruticulose - a. (L. *sub*, under, below; *frutex*, a shrub) moderately frutescent; obscurely shrubby; usually woody only basally.
Sulcate - a. (L. *sulcus*, a furrow) furrowed, grooved; scored with deep, parallel furrows or grooves.
Suture - n. (L. *suere*, to sew) a seam formed when two parts unite; a seam or line or groove; usually applied to the line along which a fruit dehisces; any lengthwise groove that forms a junction between two parts.
Swale - n. (Sw. *sval*, cool) a hollow or depression, especially one in wet, marshy ground.
Swamp - n. (Sw. *svampig*, swampy) spongy land; low ground filled with water; a wooded area having surface water much of the time.
Sympodial - a. (Gr. *syn*, with; *pous*, foot) branching, growth of axillary shoots when apical budding has ceased.
Syncarp - n. (Gr. *syn*, together; *karpos*, fruit) a multiple or aggregate fruit derived from numerous separate ovaries of a single flower; a collective unit, as a blackberry.
Syntepalous - flowers in which the sepals are fused.
Taenia - n. (Gr. *tainia*, a ribbon or tape) formation of ribbon-like structure with little or no differentiation between the leaf blade and stem.
Tannins - n. (L. *tannum*, oak bark) complex aromatic compounds some of which are glucosides, possibly giving protection or concerned with pigment formation.
Taxon - n. (Gr. *taxis*, arrangement) a taxonomic category or unit, as a species or genus.
Taxonomy - n. (Gr. *taxis*, arrangement; *nomos*, law) a science that includes identification, nomenclature, and classification of objects, and is usually restricted to objects of biological origin; orderly classification of plants according to their presumed natural relationships forming a basic biological discipline involving during its Linnean period the firm establishment of binomial nomenclature and acceptance of the static concept of fixity of the species, during its Darwinian period the dynamic concept of speciation by natural selection, and during its modern Mendelian epoch an expansion to include study of the mechanisms underlying speciation and related processes.
Tendril - n. (O.Fr. *tendrillon*, tender sprig) a slender twining or clasping process, modified stem, leaf, or part of a leaf, by which some plants climb.

Tepal - n. (Fr. *tepale*, from petale) denoting a unit of the perianth when the sepals and petals are essentially alike and not readily differentiated.
Terete - a. (L. *teres*, round, smooth) nearly cylindrical in cross-section, as stems.
Ternate - a. (L. *terni*, three each) growing in groups of threes, as some leaves.
Testa - n. (L. *testa*, shell) the hard outer covering or integument of seed.
Thalloid - a., of or resembling a thallus.
Thallophyta - n. pl. (Gr. *thallos*, a young shoot; *phyton*, a plant) a primary division of plants including all forms consisting of one cell and cell aggregates not clearly differentiated into root, stem, and leaf, including bacteria, algae, fungi, and lichens.
Thallus - n. (Gr. *thallos*, a young shoot) a plant body that lacks differentiation into distinct forms of stems, leaves, roots, and does not grow from an apical point.
Therophytes - n. (Gr. *theros*, summer; *phyton*, a plant) an annual plant that overwinters as a seed.
Thorn - n. (ME., fr. OE.; akin to OHG. *dorn*, thorn, ON. *thorn*, Goth. *thaurnus*, thorn, Skt. *trna*, grass, blade of grass) a sharp rigid process on a plant; specif., a short, indurated, sharp-pointed, and leafless branch developed from a bud in a manner typical to a leafy branch.
Throat - n. (Gr. *drossel*, the gullet) term applied to an expanded part of a corolla tube just below the lobes.
Thyrseus - n. (Gr. *thyrsos*, wand) a panicle-like inflorescence consisting of a slender indeterminate main axis with lateral axes determinate, i.e., cymose.
Tiller - n. (OE. *telgor*, *telgra*, branch, twig, shoot) sprout, stalk, especially one from the base of a plant or from the axils of its lower leaves.
Tissue culture - The production of new plants from small amounts of plant tissue under carefully controlled laboratory conditions. The use of specialized methods to mass produce plants starting with small amounts of plant tissue.
Tomentose - a. (L. *tomentum*, down) densely covered with short, matted hair.
Tracheophyta - n. (LL. *trachia*, windpipe; and Gr. *phyton*, plant) a division of plants comprising green plants with a vascular system that contains tracheids or tracheary elements, being the Pteridophyta and Spermatophyta, commonly called vascular plants.
Trichome - n. (Gr. *trichoma*, a growth of hair) an outgrowth of the plant epidermis, either hairs or scales; a hair tuft; any hairlike outgrowth of the epidermis.
Trigonal - a. (Gr. *trigonos*, triangular) triangular in cross-section as applied to stems.
Trigonous - a., trigonal; having three prominent longitudinal angles, as a style or ovary.
Trimerous - a. (Gr. *tria*, three; *meros*, part) composed of three or multiples of three.
Triploid - n. (Gr. *triplus*, triple) having or being a chromosome number three times the monoploid number.
Triquetrous - a. (L. *triquetrus*, three-cornered) triangular; having a triangular cross section.
Tristichous - a. (Gr. *tria*, three; *stichos*, row) arranged in three vertical rows.
Truncate - a. (L. *truncatus*, cut off) terminating abruptly, as if tapering end were cut off; cut squarely across, either at the base or apex of an organ.
Trunk - n. (OFr. *trone*; fr. L. *truncus*, a trunk, stock, stem) the main stem or body of a tree, considered apart from its roots and branches.
Tuber - n. (L. *tuber*, a swelling or knob on plants) the short, thickened fleshy food-storing portion of an underground stem with many surface buds, generally shaped like a rounded protuberance. A swelling of root or underground stalk that functions as a storage organ as in a potato.
Tubercle - n. (L. *tuberculum*, a swelling) a small rounded protuberance; root swelling or nodule; bubil; a surficial nodule; a thickened, solid, spongy crown or cap, as on an achene; a small tuber or tuberlike growth.

Turbinate - a. (L. *turbinatus*, whirl, rotation) inversely conical; shaped like a cone resting on its apex.
Turion - n. (L. *turio*, shoot) young scaly shoot budded off from underground stems, detachable winter bud used for perennation in many aquatic plants.
Twig - n. (AS. *twigge*, twig) a small shoot or branch of a tree or other plant.
Umbel - n. (L. *umbella*, dim. of *umbra* shadel) an arrangement of flowers springing from a common center and forming a flat or rounded cluster.
Umbellate - a., bearing umbels; consisting of umbels; forming an umbel or umbels.
Unisexual - a. (L. *unus*, one; *sexus*, sex) of one or other sex, staminate or pistillate only, but not both.
Urceolate - a. (L. *urceolus*, a pitcher) shaped like a pitcher or urn.
Utricle - n. (L. *utriculus*, a little bag or bottle) an air bladder of aquatic plants; membranous indehiscent 1-celled fruit.
Valvate - adj. (NL. *valvatus*, fr. L., having folding doors) meeting at the edges without overlapping; opening as if by doors or valves.
Variety - n. (L. *varietas*, variety) a taxonomic group below the species used in different senses by different specialists, including a race, stock, strain, breed, subspecies, geographical race, or mutant.
Vascular bundle - a group of specialized cells consisting of xylem and phloem, sometimes separated by a strip of cambium and arranged in different patterns.
Vascular cambium - lateral meristem that forms the secondary tissue and is located between the xylem and phloem.
Vegetative cone - Growing tip of the plant. On a stem plant, it is the tip of the stem. On a rosette plant, it arises from the very center of the rosette.
Vegetative reproduction - Reproduction via means other than sexual. Unless a mutation occurs, each generation of new plants is identical to the parent plant genetically.
Velamen - n. (L. *velamen*, covering) a membrane; water-storing tissue in the outer layer of some roots.
Vernal - a. (L. *vernalis*, of the spring) belonging to the spring; appearing or occurring in spring; of the spring season.
Verrucose - a (L. *verrucosus*, full of warts, warty) warty; having little warts or wartlike growth on the surface.
Versatile - a. (L. *versatillis*, turning around) turning freely on its support, as an anther attached near the middle and capable of swinging freely on the filament.
Verticil - n. (L. *verticillus*, whorl) an arrangement of leaves, flowers, inflorescences, or other structures which surround the stem in a circle upon the same plane about the same point on the axis.
Verticillate - a. (L. *verticillus*, whorl) growing in a whorl or arranged on the same plane around an axis, as flowers, leaves, branches, etc.; arranged in verticils, whorled.
Vesicle - a. (L. *vesicula*, bladder) any small bladderlike structure, cavity, sac, or cyst; a small bladderlike sac filled with air.
Vestiture - n. (L. *vestitus*, grament) that which covers a surface, as hairs, scales, etc.
Villous - n. (L. *villosus*, hairy) pubescent; shaggy; covered with fine long hairs, but the hairs not matted.
Viscid - a. (L. *viscum*, bird lime) thick, syrupy, and sticky; viscous; covered with a viscid substance as of leaves.
Viviparous - a. (L. *vivus*, alive; *parere*, to produce) producing young alive rather than in eggs, as in most mammals; multiplying by vegetative means such as buds or bulbils in the position of flowers.

Wet weight - same as fresh weight; weight of plants after the outer surface covering of water has been removed. Wet weight is not a reliable measurement since methods to prepare plants prior to weighing vary considerably.
Wet woodland - a wooded area having surface water some of the time, for intermittent short periods.
Whorl - n. (AS. *hweorfan*, to turn) circle of flowers, parts of a flower, or leaves arising from one point; verticil.
Whorled - a., when three or more leaves are arranged at the same level on a stem, typical of such plants as hydrilla.
Woody - a. (ME. *woddy*, *wody*, fr. *wode*, wood + -y) of or containing wood or wood fibers; consisting mainly of hard lignified tissues.
Xeric - a. (Gr. *xeros*, dry) characterized by a scanty supply of moisture, tolerating, or adapted to, arid conditions.
Xylem - n. (Gr. *xylon*, wood) woody tissue that is part of the water-transporting system in plants, consisting of lignified tracheids or vessels, and which also acts as a supporting tissue.
Yield - n. (AS. *glidan*, to pay, restore, give up) standing crop expressed as a rate, i.e., g dry weight per meter square per day.
Zygomorphic - a. (Gr. *zygon*, yoke; *morphe*, shape) said of the corolla or calyx when divisible into equal halves in one plane only bilaterally symmetrical, with only one plane of symmetry.

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